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GENERAL INFORMATION

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The Sanatorium Medical Journal is the official publication of Atatürk Sanatoryum Training and Research Hospital. It is published online three times a year, in January–April, May–August, and September–December. The journal's content is exclusively in English, and the entire submission, review, and publication process is free of charge.

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- The letter should include the corresponding author's contact details and a declaration of any conflicts of interest.

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- An abstract of **maximum 500 words** (for original research articles, invited reviews, and case reports) and avoid references.
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Article Type	Word Count	Abstract Word Count	References	Authors	Number Figures and Tables
Original Article	3500	500	30	8	5
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Case Report/Series	2000	500	20	6	3
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- **Introduction:** Clearly define the research question, objectives, and background. The introduction should be kept concise, avoiding the repetition of widely known general information, as it is one of the shortest sections of the manuscript.
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Invited Review

Airway Techniques

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Abstract

Airway management is a fundamental practice of vital importance in numerous clinical specialties, including anesthesiology, emergency medicine, and intensive care. In this review, commonly used techniques in clinical practice —bag-mask ventilation, endotracheal intubation methods (direct laryngoscopy, video laryngoscopy, and flexible bronchoscopic intubation), extraglottic airway devices (LMA, Combitube), and surgical airway techniques (cricothyrotomy and tracheotomy)— have been evaluated in light of the most current evidence. The advantages, limitations, clinical indications, and procedural details of each technique have been discussed in depth. The available data demonstrate that the choice of airway method varies according to the patient's profile and the urgency of the clinical situation. Advanced technological approaches improve success rates in difficult airway scenarios, while extraglottic and surgical interventions offer life-saving solutions during emergencies. Airway management should be approached holistically, encompassing not only technical execution but also accurate assessment, appropriate equipment selection, and sound clinical decision-making. Consequently, it is critically important for healthcare professionals to be proficient in all airway techniques and to continuously update their skills in order to ensure patient safety.

Keywords

airway management, bag mask ventilation, intubation, extraglottic airway techniques, surgical airway techniques

Introduction

Airway management is a fundamental skill required in various medical specialties, including emergency medicine, anesthesiology, and intensive care. Ensuring airway patency and maintaining adequate oxygenation and ventilation are critical for preserving the patient's vital functions. Properly applied airway techniques can prevent life-threatening complications such as aspiration, hypoxia, and hypercapnia [1].

The techniques used for airway management vary depending on several factors, including the patient's clinical condition, anatomical features, and the available equipment. With the advancement of modern technology, airway management encompasses a broad range of techniques, and their appropriate application has a direct impact on patient outcomes [2].

This review aims to discuss the fundamental techniques used in airway management. It will first examine basic airway maintenance methods such as bag-mask ventilation, followed by an evaluation of advanced airway techniques including direct laryngoscopy, video laryngoscopy, and flexible bronchoscopic intubation. Additionally, extraglottic airway devices and surgical airway management options will also be discussed.

Bag-Mask Ventilation

Bag-mask ventilation (BMV) is one of the most fundamental and frequently employed techniques in airway management. It is primarily used to ensure oxygenation and ventilation in patients who are apneic or exhibit inadequate spontaneous breathing. BMV plays a vital role in emergency situations, anesthesia induction, and resuscitation procedures [3].

The indications for BMV are presented in **Table 1**. Difficult BMV is encountered in approximately 5–9% of the population. Predictors of difficult BMV and intubation include increased body weight and neck circumference, snoring, obstructive sleep apnea, advanced age, edentulism, and a Mallampati score of class III or IV [4]. In certain conditions—such as severe airway obstruction, facial trauma, or anatomical deformities—BMV may prove insufficient. In patients at high risk of gastric regurgitation, BMV is often avoided due to the potential for aspiration of gastric contents. The risk of pulmonary aspiration is notably increased in patients with a full stomach, hiatal hernia, pharyngeal diverticulum, or esophageal motility disorders. Prolonged suboptimal BMV involving high peak inspiratory flows and pressures can lead to gastric insufflation, which increases intragastric pressure, elevates the diaphragm, restricts lung movement, reduces respiratory system compliance, and consequently raises the peak airway pressures required for effective ventilation [5,6].

Table 1: Indications for Bag-Mask Ventilation

• As part of basic life support in patients experiencing cardiac or respiratory arrest
• For preoxygenation prior to endotracheal intubation
• To provide alternative ventilatory support in cases of failed or delayed intubation
• For temporary ventilatory support in patients with respiratory depression not requiring a surgical airway

The face mask was introduced in 1847 by British physician John Snow for the administration of inhalational anesthesia and remains the oldest airway management device still in use today [7]. Proper placement of the mask on the face is essential to ensure optimal airway patency and to prevent air leakage. The generic left-hand 'E-C' technique is performed with the thumb and index finger resting on the dome (the 'C'), the third and fourth on the mandible and the fifth at the mandibular angle (the 'E') [8]. In two-handed mask ventilation techniques, an optimal seal is achieved, and airway patency is maintained through a bilateral jaw thrust maneuver. However, a second provider is required to operate the ventilation bag [9]. To evaluate the effectiveness of ventilation, it is essential to observe chest rise, utilize capnography, and monitor oxygen saturation [10].

Endotracheal Intubation Techniques

1. Direct Laryngoscopy

Direct laryngoscopy is a fundamental technique in airway management that allows for visual guidance of the endotracheal tube during intubation. This method is widely used to establish a secure and effective airway in patients with respiratory failure or those requiring surgical anesthesia [11]. The indications for endotracheal intubation are listed in **Table 2**; these also represent contraindications for noninvasive ventilation [12].

Table 2: Indications for Endotracheal Intubation (and Contraindications for Noninvasive Ventilation)

• Respiratory arrest
• Unable to fit mask
• Medically unstable condition
• Agitated and uncooperative patient
• Inability to maintain airway patency
• Absence of swallowing (protective) reflexes
• Multiple organ failure
• Failed noninvasive ventilation

In adults, the Macintosh Laryngoscope Blade is most commonly used for direct laryngoscopy. The blade is inserted along the floor of the mouth, directed to the right side of the tongue. By displacing the tongue to the left and elevating the mandible, the soft tissues within the submandibular space are compressed. This allows the operator to visualize the vocal cords and insert the endotracheal tube into the trachea. When using a Miller blade, the tip is placed posterior to the epiglottis and is used to lift it directly. Anatomical causes of difficult direct laryngoscopy may be summarized within the three-column model of difficult airways **(Table 3)** [13].

Preoxygenation is recommended for patients undergoing endotracheal intubation. This increases the oxygen reserve in the lungs and helps prevent desaturation during the intubation process [14]. Patients should be positioned appropriately and intubated using an endotracheal tube whose cuff has been checked in advance. Placing the patient in the "sniffing position"—a combination of lower cervical flexion and upper cervical extension, first described by Kirstein in the late 1800s—helps align the oropharyngeal and laryngotracheal curves. This alignment facilitates airway manipulation and improves the likelihood of successful direct laryngoscopy [15]. In intubated patients, it is essential to confirm correct placement of the endotracheal tube within the trachea.

Table 3: The three-column model of difficult airways

Anterior column (formed by the mandible and submandibular tissues)	Middle column (formed by the airspace)	Posterior column (formed by the cervical spine)
Reduced volume (e.g. short mandible or short thyromental distance) that limits the space into which tissues can be compressed	Laryngeal tumours	Ankylosing spondylitis
Reduced compliance of soft tissues (e.g. haematoma, infection, mass or previous radiotherapy to submandibular tissues) making compression more difficult	Lingual tonsillar hypertrophy	Manual in-line neck stabilisation
		Obesity, especially patients with enlarged dorsocervical fat pads ('buffalo humps') which prevent the head extending backwards

Chest auscultation (five-point auscultation: lung apices, axillae, and epigastrium) and capnography are the most commonly used verification methods in clinical practice [16].

When direct laryngoscopy is inadequate or unsuccessful, alternative methods such as video laryngoscopy and flexible bronchoscopic intubation can be utilized to achieve endotracheal intubation.

2. Video Laryngoscopy

Video laryngoscopy is a technique that enhances visualization during airway management and facilitates the intubation process. A high-resolution camera is mounted on the laryngoscope blade, and the image is displayed on a screen. Compared to traditional direct laryngoscopy, it provides a wider viewing angle of the vocal cords and significantly increases the success rate, particularly in difficult intubation cases [17,18].

Video laryngoscopes can be classified into three main types based on the blade design:

- Macintosh-like blade,
- Hyperangulated blade,
- Blade with an integrated tracheal tube-guiding channel (i.e. a conduit) [19].

Whether video laryngoscopy should be used routinely in place of direct laryngoscopy or reserved for patients with anticipated or identified difficult airways remains a topic of ongoing debate. However, it is well established that the experience level of non-physician providers can often overcome many of the technical challenges associated with video laryngoscopy [20,21].

3. Flexible Bronchoscopic Intubation

Flexible bronchoscopic intubation (FBI) is an advanced intubation technique used in the management of difficult airways. It is performed using fiberoptic bronchoscopes and is particularly preferred for securing the airway in patients with anatomical abnormalities or cervical spine instability. One of the key advantages of FBI is its ability to be performed not only under general anesthesia in an unconscious patient, but also in an awake patient [22].

Prior to performing FBI, it is essential to ensure that the device has been properly cleaned. After positioning the patient in a semi-recumbent or supine position, the bronchoscope is advanced either orally or nasally. The epiglottis, vocal cords, and trachea are visualized as the bronchoscope is directed into the trachea. Once the trachea is reached, the endotracheal tube is advanced over the bronchoscope under direct visualization, and the bronchoscope is then withdrawn [23].
Despite its widespread use today, complications such as airway bleeding—particularly during awake fiberoptic intubation—as well as obstruction and regurgitation, can still occur. These issues may occasionally lead to failure of the technique and necessitate the use of surgical airway interventions [24].

Extraglottic Airway Techniques

1. Laryngeal Mask Airways

The laryngeal mask airway (LMA), developed in the 1980s, is a supraglottic device widely used in both surgical anesthesia and emergency airway management. Originally designed as an alternative to endotracheal intubation, it provides an effective solution particularly in short-duration surgeries and in cases where intubation is difficult [25,26].

The LMA consists of a soft mask that is positioned in the pharynx and covers the laryngeal inlet, along with

The LMA consists of a soft mask that is positioned in the pharynx and covers the laryngeal inlet, along with an attached airway tube. The mask component is surrounded by an inflatable cuff, which creates a seal in the hypopharynx, allowing for effective ventilation. For insertion, the patient is positioned supine with the head extended. The LMA is advanced along the hard palate into the hypopharynx. Once the cuff is properly inflated, it seals the glottic opening, enabling ventilation [27]. **Table 4** outlines the advantages and disadvantages of the laryngeal mask airway [28-30].

Table 4: Advantages and disadvantages of LMA

Advantages	Disadvantages
• Less invasive compared to endotracheal intubation.	• Does not provide adequate protection against aspiration.
• Easy to use and requires less clinical experience.	• Ventilation may be compromised if the device becomes displaced.
• Short insertion time allows for rapid airway establishment.	• Air leakage may occur in certain patient positions.
• Does not require neck or head movement; advantageous in trauma patients.	• Not suitable for long-term ventilation.
• Minimal hemodynamic responses.	• May cause complications such as hypopharyngeal trauma and tongue edema.

Over time, various models of the LMA have been developed [30-33]:
Classic LMA™: The original model, primarily used in routine surgical procedures.
LMA ProSeal™: Contains a gastric drainage tube to reduce the risk of aspiration.
LMA Supreme™: A single-use device with a rigid structure designed for easier insertion and gastric drainage.
LMA Fastrach™: Also known as the "intubating LMA," it facilitates fiberoptic intubation.

2. I-gel

The i-gel is an extraglottic airway device with a supraglottic placement that has gained widespread use over the past two decades. It is anatomically shaped and made of a gel-like thermoplastic elastomer, from which it derives its name—reflecting both its "i"-shaped anatomical design and its soft, gel-like composition. This structure allows the device to conform anatomically to the pharyngeal and laryngeal structures without the need for cuff inflation. Developed as an alternative to balloon-inflated laryngeal masks, the i-gel provides an effective airway solution in both emergency and elective settings [34,35].

A full range of pediatric sizes is available, and the device consists of three main components. The mask portion does not require cuff inflation; it provides passive sealing through anatomical conformity. An integral bite block helps prevent airway occlusion during trismus or involuntary biting. The gastric drainage channel allows the insertion of an orogastric tube for gastric decompression, thereby reducing the risk of aspiration [35,36].

Insertion is performed in the sniffing position and requires that the i-gel is lubricated on all surfaces before insertion. Standard insertion mimics LMA insertion with the passage of the i-gel following the roof of the mouth and posterior pharynx until stopped by cricopharyngeus muscles [35,37].

The i-gel offers several advantages over the classic LMA, particularly due to its cuffless design and anatomical conformity. It facilitates more rapid airway establishment and reduces the risk of complications [37].

3. Combitube

The Combitube is a dual-lumen, dual-cuff extraglottic airway device developed for emergency airway management. It offers a rapid and effective alternative, particularly in prehospital and in-hospital emergency settings where intubation is difficult or not feasible. Its unique value lies in the ability to ventilate the lungs regardless of whether the device is positioned in the esophagus or the trachea. It was designed by Dr. Michael Frass in Austria in 1983 [38].

The device features two cuffs: a large oropharyngeal balloon located in the mid-portion of the tube and a smaller tracheoesophageal balloon situated distally. The two lumens are separated by a partition; one lumen is closed at the distal end and facilitates ventilation via eight side perforations located between the two cuffs, while the other lumen has an open distal tip. This design allows for ventilation through the perforated lumen when the Combitube is placed in the esophagus, and through the open-tip lumen when it is inserted into the trachea. The Combitube is designed for blind insertion with the patient's head in the neutral position, and it most commonly enters the esophagus when inserted blindly [39].

The advantages and disadvantages of the Combitube are summarized in **Table 5** [30,40].

Table 5: Advantages and disadvantages of Combitube

Advantages	Disadvantages
• Can be inserted blindly; does not require advanced skills.	• Intended for short-term use; not suitable for prolonged ventilation.
• Allows rapid insertion, saving time in emergencies.	• Overinflation of cuffs may cause tissue damage.
• Esophageal placement reduces the risk of pulmonary aspiration.	• Carries a risk of gastrointestinal complications (e.g., esophageal injury, gastric distension).
• Does not require head or neck manipulation, making it suitable for patients needing spinal stabilization.	• The rigid structure of the tube may cause oropharyngeal trauma.
• Serves as a bridge to endotracheal intubation.	• Not suitable for pediatric patients; only available in adult sizes.

Surgical Airway Techniques

1. Cricothyrotomy

Cricothyrotomy is one of the emergency airway management techniques and is considered the last resort in most airway management protocols. It is a life-saving intervention, particularly in “cannot intubate, cannot oxygenate” (CICO) scenarios [41].

Surgical cricothyrotomy has long been a standard of emergency invasive airway rescue; however, its use has declined, in part because of advances in noninvasive airway devices such as supraglottic airways and video laryngoscopes, the adoption of rapid sequence intubation in the emergency department, and increased requirements for trainee supervision [42].

The procedure is based on surgically opening the cricothyroid membrane to gain direct access to the trachea. This membrane is considered the most accessible part of the airway below the glottis [43]. Emergency cricothyrotomy may be performed in prehospital settings, emergency departments, intensive care units, or operating rooms. Elective cricothyrotomy is generally performed in the operating room prior to certain surgical procedures. It may also be performed bedside in critically ill ICU patients [44].

Cricothyrotomy can be performed via percutaneous or surgical techniques: In the percutaneous technique, a large-bore needle is inserted into the cricothyroid membrane under sterile conditions. Correct intratracheal positioning is confirmed by aspiration of air. A guidewire is then passed through the needle, followed by the insertion of a small-diameter cannula into the trachea over the wire. In the surgical technique, the patient is placed in the supine position with slight neck extension. The thyroid and cricoid cartilages are palpated, and the cricothyroid membrane between them is identified. A vertical skin incision is made over the membrane, followed by a horizontal incision through the membrane itself. A small-diameter endotracheal tube or tracheotomy cannula is then inserted into the trachea [45].

Despite being a life-saving procedure, cricothyrotomy carries potential complications, including bleeding, subcutaneous emphysema, esophageal perforation, infection, and long-term tracheal stenosis [46,47].

2. Tracheo(s)tomy

“Tracheotomy” is the operation of ‘opening the trachea’, derived from the Greek words trachea arteria (rough artery) and tome (cut). “Tracheostomy” has an ending derived from the Greek word stoma (opening or mouth) [48]. These two terms are often used interchangeably in clinical practice. Throughout this manuscript, the procedure will be referred to as "tracheotomy."

Tracheotomy is the procedure by which access to the trachea is obtained via a surgical incision between the second and fourth tracheal rings, and the airway is maintained by placement of a tracheotomy cannula. It is generally performed in patients requiring prolonged ventilation or those with long-term upper airway obstruction. Although it can be performed emergently in cases of acute airway obstruction, tracheotomy is more commonly undertaken as an elective procedure. This intervention serves both to facilitate ventilation and to bypass the upper airway [49].
The four primary indications for tracheotomy are prolonged mechanical ventilation, failure to wean from the ventilator, upper airway obstruction, and copious secretions [48,50]. Similar to cricothyrotomy, tracheotomy may be performed using either a percutaneous or a surgical approach. The percutaneous technique is typically performed at the bedside in the intensive care unit, whereas the surgical approach is usually reserved for the operating room. In the percutaneous method, the Seldinger technique is employed: a needle and guidewire are used to access the trachea under sterile conditions, the tract is sequentially dilated with dilators, and finally a tracheotomy cannula is inserted.

In the surgical technique, the patient is placed supine with the neck in extension. A vertical incision is made through the skin and subcutaneous tissue. Because the thyroid isthmus often covers the lower tracheal rings, it is carefully retracted superiorly or inferiorly. A horizontal incision is then made between the second and third tracheal rings, after which the tracheotomy cannula is inserted and secured [48-50]. Proper fixation of the tracheotomy cannula and meticulous skin care are essential to minimize the risk of infection.

The cannula should be regularly cleaned and monitored for obstruction or secretion buildup. Use of a speaking valve or heat–moisture exchanger may be required to optimize humidification and enable phonation. The decannulation or tracheotomy closure process is planned based on the patient's respiratory adequacy and clinical status [51].

The fundamental differences between cricothyrotomy and tracheotomy are summarized in **Table 6**.

Table 6: Differences Between Cricothyrotomy and Tracheotomy

Feature	Cricothyrotomy	Tracheotomy
Purpose	Temporary airway in emergency situations	Elective or long-term airway management
Procedure time	Very rapid (1–3 minutes)	Longer duration (10–20 minutes)
Technical difficulty	Relatively easy	More complex
Complication rate	Lower in the short term	Lower in the long term
Age group	Applicable in adults only	Can be performed in all age groups

Conclusion

Timely and effective application of appropriate airway management techniques not only increases a patient's chance of survival but also significantly reduces the risk of complications. Therefore, it is vital that clinicians possess adequate knowledge and experience not only in primary methods but also in alternative and advanced airway techniques.

Today, airway management is not merely a set of technical procedures; it is a comprehensive process that requires pre-assessment, an algorithmic approach, appropriate equipment selection, and multidisciplinary collaboration. The success of this process is directly linked to the clinician's knowledge base, skill level, and decision-making capacity.

In conclusion, considering the wide range of airway techniques and their respective roles in various clinical contexts, physicians must act not only as practitioners but also as strategic decision-makers capable of selecting the most appropriate method for each situation. Mastery in airway management—achieved through education, simulation training, and continuous professional development—is essential for ensuring patient safety and successful outcomes.

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ET participated in the planning, writing, and review this paper.

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References

1. Cook TM. Strategies for the prevention of airway complications - a narrative review. Anaesthesia. 2018;73(1):93-111.
2. Cooper RM. Strengths and limitations of airway techniques. Anesthesiol Clin. 2015;33(2):241-55.
3. Khoury A, Hugonnot S, Cossus J, et al. From mouth-to-mouth to bag-valve-mask ventilation: evolution and characteristics of actual devices--a review of the literature. Biomed Res Int. 2014;2014:762053.
4. El-Orbany M, Woehlck HJ. Difficult mask ventilation. Anesth Analg. 2009;109(6):1870-80.
5. Isono S, Eikermann M, Odaka T. Facemask ventilation during induction of anesthesia: how "gentle" is "gentle" enough? Anesthesiology. 2014;120(2):263-5.
6. Wenzel V, Idris AH, Dorges V, et al. The respiratory system during resuscitation: a review of the history, risk of infection during assisted ventilation, respiratory mechanics, and ventilation strategies for patients with an unprotected airway. Resuscitation. 2001;49(2):123-34.
7. Holzman RS. John Snow: Anesthesiologist, Epidemiologist, Scientist, and Hero. Anesth Analg. 2021;133(6):1642-50.
8. Matioc AA. An Anesthesiologist's Perspective on the History of Basic Airway Management: The "Modern" Era, 1960 to Present. Anesthesiology. 2019;130(5):686-711.
9. Isono S. One hand, two hands, or no hands for maximizing airway maneuvers? Anesthesiology. 2008;109(4):576-7.
10. Bell D. Avoiding adverse outcomes when faced with 'difficulty with ventilation'. Anaesthesia. 2003;58(10):945-8.

11. White GM. Evolution of endotracheal and endobronchial intubation. Br J Anaesth. 1960;32:235-46.
12. Nava S, Hill N. Non-invasive ventilation in acute respiratory failure. Lancet. 2009;374(9685):250-9.
13. Greenland KB. Airway assessment based on a three column model of direct laryngoscopy. Anaesth Intensive Care. 2010;38(1):14-9.
14. Tanoubi I, Drolet P, Donati F. Optimizing preoxygenation in adults. Can J Anaesth. 2009;56(6):449-66.
15. Zeitels SM. Universal modular glottiscope system: the evolution of a century of design and technique for direct laryngoscopy. Ann Otol Rhinol Laryngol Suppl. 1999;179:2-24.
16. Ortega R, Connor C, Kim S, Djang R, Patel K. Monitoring ventilation with capnography. N Engl J Med. 2012;367(19):e27.
17. Niforopoulou P, Pantazopoulos I, Demestiha T, Koudouna E, Xanthos T. Video-laryngoscopes in the adult airway management: a topical review of the literature. Acta Anaesthesiol Scand. 2010;54(9):1050-61.
18. Lewis SR, Butler AR, Parker J, Cook TM, Schofield-Robinson OJ, Smith AF. Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation: a Cochrane Systematic Review. Br J Anaesth. 2017;119(3):369-83.
19. Berkow LC, Morey TE, Urdaneta F. The Technology of Video Laryngoscopy. Anesth Analg. 2018;126(5):1527-34.
20. Maissan I, van Lieshout E, de Jong T, et al. The impact of video laryngoscopy on the first-pass success rate of prehospital endotracheal intubation in The Netherlands: a retrospective observational study. Eur J Trauma Emerg Surg. 2022;48(5):4205-13.
21. Savino PB, Reichelderfer S, Mercer MP, Wang RC, Sporer KA. Direct Versus Video Laryngoscopy for Prehospital Intubation: A Systematic Review and Meta-analysis. Acad Emerg Med. 2017;24(8):1018-26.
22. Benumof JL. Management of the difficult adult airway. With special emphasis on awake tracheal intubation. Anesthesiology. 1991;75(6):1087-110.
23. Collins SR, Blank RS. Fiberoptic intubation: an overview and update. Respir Care. 2014;59(6):865-78; discussion 78-80.
24. Cook TM, Woodall N, Frerk C, Fourth National Audit P. Major complications of airway management in the UK: results of the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society. Part 1: anaesthesia. Br J Anaesth. 2011;106(5):617-31.
25. Brain AI, McGhee TD, McAteer EJ, Thomas A, Abu-Saad MA, Bushman JA. The laryngeal mask airway. Development and preliminary trials of a new type of airway. Anaesthesia. 1985;40(4):356-61.
26. Maltby JR, Loken RG, Watson NC. The laryngeal mask airway: clinical appraisal in 250 patients. Can J Anaesth. 1990;37(5):509-13.
27. Asai T, Morris S. The laryngeal mask airway: its features, effects and role. Can J Anaesth. 1994;41(10):930-60.
28. Brimacombe J. The advantages of the LMA over the tracheal tube or facemask: a meta-analysis. Can J Anaesth. 1995;42(11):1017-23.
29. Jannu A, Shekar A, Balakrishna R, Sudarshan H, Veena GC, Bhuvaneshwari S. Advantages, Disadvantages, Indications, Contraindications and Surgical Technique of Laryngeal Airway Mask. Arch Craniofac Surg. 2017;18(4):223-9.
30. Hernandez MR, Klock PA, Jr., Ovassapian A. Evolution of the extraglottic airway: a review of its history, applications, and practical tips for success. Anesth Analg. 2012;114(2):349-68.
31. Brain AI, Verghese C, Strube PJ. The LMA 'ProSeal'--a laryngeal mask with an oesophageal vent. Br J Anaesth. 2000;84(5):650-4.
32. Hosten T, Gurkan Y, Ozdamar D, Tekin M, Toker K, Solak M. A new supraglottic airway device: LMA-supreme, comparison with LMA-Proseal. Acta Anaesthesiol Scand. 2009;53(7):852-7.
33. Ferson DZ, Rosenblatt WH, Johansen MJ, Osborn I, Ovassapian A. Use of the intubating LMA-Fastrach in 254 patients with difficult-to-manage airways. Anesthesiology. 2001;95(5):1175-81.
34. Bamgbade OA, Macnab WR, Khalaf WM. Evaluation of the i-gel airway in 300 patients. Eur J Anaesthesiol. 2008;25(10):865-6.
35. Gabbott DA, Beringer R. The iGEL supraglottic airway: a potential role for resuscitation? Resuscitation. 2007;73(1):161-2.
36. Maitra S, Baidya DK, Bhattacharjee S, Khanna P. Evaluation of i-gel() airway in children: a meta-analysis. Paediatr Anaesth. 2014;24(10):1072-9.
37. de Montblanc J, Ruscio L, Mazoit JX, Benhamou D. A systematic review and meta-analysis of the i-gel((R)) vs laryngeal mask airway in adults. Anaesthesia. 2014;69(10):1151-62.
38. Frass M, Frenzer R, Rauscha F, Weber H, Pacher R, Leithner C. Evaluation of esophageal tracheal combitube in cardiopulmonary resuscitation. Crit Care Med. 1987;15(6):609-11.
39. Vaida S, Gaitini L, Frass M. Supraglottic Airway Techniques: Nonlaryngeal Mask Airways. In: Hagberg CA, Artime CA, Aziz MF, editors. Hagberg and Benumof's Airway Management. 4th ed. Philadelphia, PA: Elsevier; 2018. p. 420-46.
40. Agro F, Frass M, Benumof JL, Krafft P. Current status of the Combitube: a review of the literature. J Clin Anesth. 2002;14(4):307-14.
41. Heidegger T, Gerig HJ, Ulrich B, Kreienbuhl G. Validation of a simple algorithm for tracheal intubation: daily practice is the key to success in emergencies--an analysis of 13,248 intubations. Anesth Analg. 2001;92(2):517-22.
42. Manoach S, Corinaldi C, Paladino L, et al. Percutaneous transcricoid jet ventilation compared with surgical cricothyroidotomy in a sheep airway salvage model. Resuscitation. 2004;62(1):79-87.

43. Gulsen S, Unal M, Dinc AH, Altinors N. Clinically correlated anatomical basis of cricothyrotomy and tracheostomy. J Korean Neurosurg Soc. 2010;47(3):174-9.
44. Holst M, Hedenstierna G, Kumlien JA, Schiratzki H. Five years experience of coniotomy. Intensive Care Med. 1985;11(4):202-6.
45. Chan TC, Vilke GM, Bramwell KJ, Davis DP, Hamilton RS, Rosen P. Comparison of wire-guided cricothyrotomy versus standard surgical cricothyrotomy technique. J Emerg Med. 1999;17(6):957-62.
46. Gibbs MA, Mick NW. Surgical Airway. In: Hagberg CA, Artime CA, Aziz MF, editors. Hagberg and Benumof's Airway Management. 4th ed. Philadelphia, PA: Elsevier; 2018. p. 525-39.
47. Francois B, Clavel M, Desachy A, Puyraud S, Roustan J, Vignon P. Complications of tracheostomy performed in the ICU: subthyroid tracheostomy vs surgical cricothyroidotomy. Chest. 2003;123(1):151-8.
48. De Leyn P, Bedert L, Delcroix M, et al. Tracheotomy: clinical review and guidelines. Eur J Cardiothorac Surg. 2007;32(3):412-21.
49. Durbin CG, Jr. Tracheostomy: why, when, and how? Respir Care. 2010;55(8):1056-68.
50. Cheung NH, Napolitano LM. Tracheostomy: epidemiology, indications, timing, technique, and outcomes. Respir Care. 2014;59(6):895-915; discussion 6-9.
51. Morris LL, Whitmer A, McIntosh E. Tracheostomy care and complications in the intensive care unit. Crit Care Nurse. 2013;33(5):18-30.

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Original Article

The Impact of Pulmonary Infection Episodes on Lung Cancer Treatment

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Abstract

Background: Despite recent advances in the treatment of lung cancer, cytotoxic chemotherapies remain the most often utilized therapeutic modality. Pneumonia has a detrimental effect on the planned cancer treatment process. In this study, we aimed to investigate the risk factors for pneumonia in lung cancer patients and the effect of lung infection on cancer treatment process.

Methods: We retrospectively reviewed 300 patients with lung cancer who were hospitalized due to pulmonary infection. Effects of pneumonia were divided into 3 groups; treatment terminated, delayed, and unaffected. Factors that may affect the cancer treatment were examined.

Results: Microbiologically, gram negative bacteria were isolated mostly. The most preferred antibiotic treatments by clinicians were combinations of two regimens. The failure rate of first line anti-biotherapy was 35.7% (107 patients). In 128 (42.7%) patients, pulmonary infection did not affect the cancer treatment. While treatments of 95 (31.7%) patients were delayed, in 77 (25.7%) cases treatment was terminated. Febrile episode rate was higher in the chemotherapy group (with or without radiotherapy) than patients receiving other treatments (50.4% vs. 33.6%, p=0.014). The number of patients using systemic steroids and being on active chemotherapy process were higher in treatment delayed and terminated group than in the unaffected (p=0.002 and p=<0.001, respectively).

Conclusion: Because of the higher rate of failure of cancer treatment due to pneumonia in patients receiving chemotherapy, patients should be evaluated carefully before initiating treatment and pneumonia management should be maintained effectively.

Keywords
Cancer treatment, cytotoxic chemotherapy, lung cancer, pneumonia

Introduction

Lung cancer is a type of malignancy that has many complications due to tumor itself and treatment modalities. Pulmonary infection is one of the most important reasons negatively affecting the treatment process. For this group of immunosuppressed patients, there is a risk of pulmonary infection at the time of cancer diagnosis, during of treatment and can result in death. Initial assessment of performance status, co-morbidities, nutritional status, and social support of patients are important factors to predictive infective complications [1].

A study with 96 consecutive patients with visible endobronchial tumour revealed a prevalence of 34% positive culture results in BAL fluids at the time of cancer diagnosis with no relation to histology, stage, Karnofsky performance status, total lymphocyte count, or T-lymphocyte [2]. Incidence of pulmonary infections at any time of cancer management changes from 24% to 70% [3, 4]. According to a prospective study including 275 hospitalized lung cancer patients, upper and lower respiratory tract infections (n = 244; 56%) constitute the majority of infective complications [5].

Because of the low median survival in infected patients, the management and prevention of pulmonary infection is vital in patients with lung cancer [3, 6]. Either a respiratory failure after a pneumonia or disruption of cytotoxic treatment can be a reason for mortality. A report with a large study population (845 patients with small cell lung cancer (SCLC)) demonstrates that fatal infection rates were higher in patients receiving chemotherapy,

systemic steroids, mediastinal radiotherapy, with age above 60 and bad performance status [7].

The primary end point of this study is to assess effect of pulmonary infections on course of cancer treatment and secondly to demonstrate microbiological features, antibiotic choices and aggravating factors in an unselected group of lung cancer.

Material and Method

Study Design

This study was designed as a single center, retrospective, cross-sectional study.

Study Setting

The study was hold in a tertiary pulmonology center – palliative care service. All cases were taken regardless of stage and histopathological type. The inclusion criteria were having any sign suggesting respiratory tract infection. The following characteristics were main symptoms: Fever (>38˚C), cough, purulence in sputum, dyspnea, wheezing. Routine laboratory tests [hemogram, biochemical analyses, complete urine test, C-reactive protein (CRP)] were performed. Clinically documented infections (all were evaluated by pulmonologists), even if there was no positivity in culture, were accepted positive if clinical or radiologic signs were compatible with the diagnosis of lower respiratory tract infection. Febrile episode was defined as; existence of fever at the beginning of hospitalization.

Study population

A total of 300 lung cancer patients having indication of hospitalization due to lower respiratory tract infection between January 2014 to November 2018 were included. Data were collected from hospital data base. The study was approved by the Ethics Committee of the Atatürk Chest Disease and Thoracic Surgery Teaching and Research Hospital with number of 579 - 21.11.2017.

Variables, definitions, and protocols

Age, gender, histopathological type, tumour stage and type of treatment at the time of hospitalization, existence of new consolidation on chest X-ray or computed thorax tomography (CTT), existence of bronchiectasis, interstitial lung disease (ILD), chronic obstructive pulmonary disease (COPD), using systemic steroids, name of documented pathogens and antibiotic regimens were recorded from hospital data base.

Indications for using steroid includes following; COPD exacerbation, vena cava superior syndrome (VCSS), brain metastasis, lymphangitic spread.

Microbiological examination and anti-biotherapy regimens: According to clinical signs microbiological samples were collected from sputum, blood, urine, pleura, mouth, any ulcerated lesion on skin adequately. Samples were analyzed for gram staining and culture, acid-resistant bacillus (ARB) and fungal infection if necessary. All culture results detected during hospitalization were saved. Initial anti biotherapy choice, switching to new treatment regimen due to first line antibiotic treatment failure were also recorded.

Failure of initial antibiotic regimen: All patients were re-evaluated with chest X-ray, white blood cell (WBC) count, C-reactive protein (CRP), lung examination (crackle and/or rhonchi) and pulses oximetry monitoring (SpO2) on the third day of treatment in line with the routine protocol in our clinical practice and the recommendations of the international pneumonia guideline [8]. If any of these clinical tools worsened, it was considered as treatment failure and new regimen was started.

The types of cancer-treatment that patients receive when hospitalized are defined as follows: All treatment modalities were recorded for patients. These are; best supportive care (BSC), systemic chemotherapy, chemo-radiotherapy (concurrent/sequential), palliative radiotherapy (bone, cranial, thorax lesion, VCSS), curative radiotherapy, targeted therapy, adjuvant chemotherapy. Patients who completed the planned treatment were defined in ‘follow-up’ group. If the patient’s treatment is postponed due to pulmonary infection, patient was coded in ‘treatment delayed’ group. This group of patients were re-evaluated carefully during following visits and if the planned malignancy treatment could not be started, this patient was accepted as in group of 'treatment terminated'.

The effect of the pulmonary infection on the treatment process was evaluated in 3 ways; it did not effect, caused treatment to be delayed and terminated the treatment. For patients who were in follow up period/BSC, it was codded ‘it did not affect’ in database.

Statistical Analyses

The IBM SPSS Statistics 18 software package (IBM SPSS Statistics, Somers, N.Y., USA) was used for the statistical analysis. Baseline characteristics of the

study population study, were generated using descriptive analyses. Normality analyses parametric variables were performed using the Shapiro–Wilk Test, histograms, and QQ-plots. To test homogeneity of variances, Levene's test was used, and p value was above 0.05. One-way anova was used to compare numeric variables between three groups (Treatment delayed/terminated/unaffected). To compare non-parametric variables qi-square test was used.

Results

300 patients with lung cancer regardless of TNM stage were included. The mean age of study population was 64±10.1. There was male predominance with 268 (89.3%) patients and 32 (10.7%) female patients.

Majority of patients were diagnosed with NSCLC 245 (81.7%) and 55 (18.3%) patients were SCLC. NSCLC group consists of adenocarcinoma with number of 92 (30.7%) and non-adenocarcinoma including not-other wised specified (NOS) with 153 (49.7%) patients. The most common initial TNM stage was stage IV with 156 (52%) patients for NSCLC. Among SCLC patients there were 36 patients with extensive disease and 19 with limited disease. The most frequent TNM stage during hospitalization was stage IV (n=189, 63%). Characteristics of study population were summarized in **Table 1**.

Number of patients followed by BSC was 64 (21.5%). While 50 (16.8%) of patients were in follow-up period, planned treatment could not be started in 57 (19.1%) patients due to respiratory infection complication. 30 (9.7%) of patients were receiving curative treatments (chemo-radiotherapy, surgery, adjuvant chemotherapy and curative radiotherapy). Other treatments were 75 (25.2%) patients with palliative systemic chemotherapy, 10 (3 %) patients with targeted therapies and 14 (4.7%) patients with palliative radiotherapy. Distribution of treatments before hospitalization were indicated in **Figure 1.**

There were 118 (36.3%) patients with febrile episodes. There were 52 patients (50.4%) with febrile episode in chemotherapy group (n=101, with or without radiotherapy) and there were 67 patients (33.6%) in patients receiving other treatments (n=199). Rate of febrile episodes were higher in chemotherapy group with significance (p=0.014).

Chronic obstructive pulmonary disease was recorded in 127 (42.3%) patients, bronchiectasis in 14 (4.7%) patients and ILD in 6 (2%) patients.

Table 1: General characteristics of study population

Variables	Number (%) or means ± SD
Age (±SD)	64±10.1
Gender	
Female	32 (10.7%)
Male	268 (89.3%)
NSCLC[1]	245 (81.7%)
SCLC[1]	55 (18.3%)
Adenocarcinoma	92 (30.7%)
Squamous cell carcinoma	153 (49.7%)
Initial TNM stage	
-Stage I-II	29 (9.6%)
-Stage IIIA-IIIB	115 (38.4%)
-Stage IV	156 (52%)
TNM stage when hospitalized	
-Stage I-II	20 (6.4%)
-Stage IIIA-IIIB	91 (30.3%)
-Stage IV	189 (63%)
Pneumonia	142 (47.3%)
Microbiologically documented infection	121 (40.3%)
Febrile episode	118 (36.3%)
Febrile neutropenia	25 (8.3%)
Chronic parenchymal lung disease[2]	147 (47.2%)
Using systemic steroid[3]	154 (51.3%)
Creatinine ±SD *mean±SD* (mg/dL)	0.8± 2.5
Albumin *mean±SD* (g/L)	3.3±2.5
CRP *mean±SD* (mg/L)	12.2±13.6

1: NSCLC: Non-small cell lung cancer, ***SCLC:*** Small cell lung cancer, **2:** Chronic obstructive pulmonary disease (n=127), interstitial lung disease (n=6) and bronchiectasis (n=14) , **3:** COPD exacerbation, vena cava superior syndrome (VCSS), brain metastasis, lymphangitic spread.

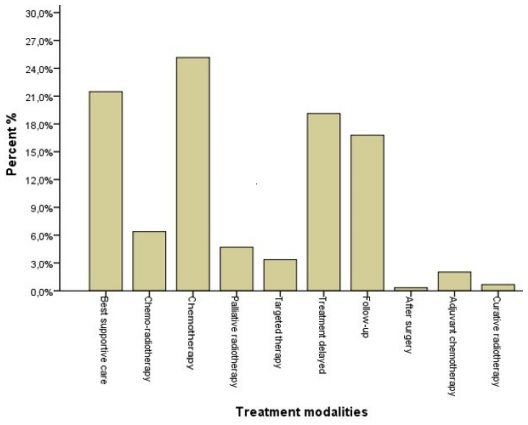

Figure 1: Frequency of treatment modalities used in the study population

There were 142 (47.3%) patients with confirmed pneumonia and 121 (40.3%) patients with identified pathogens. Most isolated bacteria were pseudomonas aeruginosa (n=18, 15 %), acinetobacter baumannii (n=14, 11 %) and enterobacteriaceae (n=17, 14.3%). Microbiological characteristics of bacteria strains were summarized in **Table 2.** Polymicrobial infections were detected in 26 (8.7%) patients and in 35 (28.9%) patients, candida infection was accompanied by as well as bacterial infection.

The most preferred antibiotic treatments by clinicians were combination of two regimens (n=100, 33.4%), quinolone (n=84, 28.1%) and anti-pseudomonas therapy (n=65, 21.8%), Failure rate of first line anti-biotherapy was 35.7% (107 patients) **(Table 2).**

Table 2: Microbiological characteristics, antibiotic preference and failure rate

Microbiological characteristics	
• Acinetobacter baumannii	14 (11 %)
• Streptococcus pneumonia	7 (5.8 %)
• Pseudomonas aeruginosa	18 (15 %)
• Haemophilus influenzae	4 (3.4 %)
• Enterobacteriaceae	17 (14.3%)
• Stenotrophomonas maltophilia	6 (5 %)
• Staphylococcus aureus	7 (5.8 %)
• Klebsiella pneumonia	6 (5 %)
• Aspergillosis spp.	7 (5.8 %)
• Candidiasis	35 (28.9 %)
The first choice of antibiotic regimens	
• Penicillin	7 (2.3%)
• 3rd generation cephalosporin	15 (5%)
• Cefepime	20 (6.7%)
• Quinolone	84 (28.1%)
• Antifungal regimen	8 (2.7 %)
• Combination of two regimens	100 (33.4%)
• Anti-pseudomonal therapy*	65 (21.8%)
Polymicrobial infections	26 (8.7%)
Failure rate of first line antibiotherapy	107 (35.7%)

*Piperacillin-tazobactam, carbapenems, cefoperazone-sulbactam

In 128 (42.7%) patients, pulmonary infection did not affect the treatment of lung cancer. While treatments of 95 (31.7%) patients were delayed, in 77 (25.7%) cases treatment of malignancy was terminated. Some predictive factors were compared between 3 groups. Percentage of patients using systemic steroids were higher in patients whose therapy was terminated than other 2 groups (n=49 (63.6%), p=0.002). There were more patients with SCLC in group of ''treatment delayed'' (n=25 (26.4%) and p=0.038) **(Table 3).** Number of patients using systemic chemotherapy (palliative or adjuvant) were higher in treatment delayed (n=43,45.2%) and terminated (n=33,42.8%) groups than unaffected (n=7, 5.4%) with significance (p<0.001).

Discussion

Our findings with 300 lung cancer patients, revealed the importance of effective management of pulmonary infection on cancer treatment. Although it is a heterogeneous cohort in terms of demographic characteristics, TNM stage and treatment types, we have actually worked with a population of locally advanced and advanced stage NSCLC cases mostly, most of which were men. Although the frequency of treatment types vary, pulmonary infection was observed during all types of cancer treatment.

Male sex, low ECOG, a central venous catheter and leukopenia were identified as risk factors for febrile episodes in a study of 377 lung cancer patients receiving chemotherapy. More importantly, febrile episodes during chemotherapy were significantly related to shorter median survival (6.1 vs 12.0 months) [9]. Survival analyses were not our endpoint or we did not consider existence of central venous catheter, however there were 120 (40%) patients with febrile episodes and febrile episode rate was significantly higher in the chemotherapy group in this study than other treatments (50.4% vs. 33.6%, p=0.014). Although, we mostly use primary prophylaxis with G-CSF in our daily practice for some patients (age above 65, multiple co-morbidities especially renal or cardiac dysfunction) it is not possible to specify a number in this regard with this study. The importance of early diagnosis and treatment of lung infection and the application of primary G-CSF prophylaxis in required patients is clearly seen especially in patients receiving chemotherapy.

The lung is a very difficult organ to manage its complications. The presence of chronic parenchymal lung diseases such as COPD, ILD and bronchiectasis increases the susceptibility to infections. Therefore, lung cancer cases with concomitant pulmonary comorbidities should be handled more carefully. Development of bacterial superinfection is facilitated by underlying chronic airway inflammation, bronchial obstruction, and mucosal damage in these patients [1]. Berghmans et al. reported that pulmonary infection rate was higher in COPD patients although not statistically significant (70.0% vs 61.1%; OR, 1.15; p=0.07) [5]. There were 127 (42.3%) patients with COPD in our study. The number of patients with chronic parenchymal lung disease did not differ between groups. It may be considered as a limiting point that, stable COPD treatments, Global Initiative for Chronic Obstructive Lung Disease (GOLD) stage or inhaler device compliance of these 127 patients were not recorded. But in our daily practice, all patients are evaluated for the presence of COPD simultaneously with the diagnosis of malignancy and appropriate long-acting bronchodilator therapy is started early. It should be

Table 3: Comparison of features between three groups according to how treatment of lung cancer was affected

Characteristics	Treatment delayed n=95 (31.7%)	Treatment terminated n=77 (25.7%)	Treatment unaffected n=128 (42.7%)	p value
Age (±SD)	63.0±9.3	61.9±10.8	65.9±9.9	**0.012**
Gender				
• Female	12	10	12	0.86
• Male	83	67	116	
NSCLC[1]	70 (73.6%)	60 (77.9%)	115 (89.8%)	**0.038**
SCLC[1]	25 (26.4%)	17 (22.1%)	13 (10.2%)	
Adenocarcinoma	25 (64.3%)	25 (55.9%)	42 (45.4%)	0.28
Non-adenocarcinoma	34 (35.7%)	34 (44.1%)	70 (54.6%)	
Initial TNM stage				
• Stage III	42 (52.7%)	21 (33.8%)	52 (54.7%)	0.55
• Stage IV	45 (47.3%)	51 (66.2%)	58 (45.3%)	
TNM stage when hospitalized				
• Stage III	36 (44.3%)	13 (20.5%)	42 (43%)	0.32
• Stage IV	53 (55.7%)	61 (79.2%)	73 (57%)	
Pneumonia	45 (47.3%)	34 (44.1%)	61 (47.6%)	0.89
CRP *mean±SD*	13.2±8.0	15.8±17.4	15.0±14.4	0.44
Albumine≤2.5	3.7±3.6	3.5±2.8	3.2±0.5	0.28
Microbiologically documented infection	28 (29.4%)	31 (40.2%)	60 (46.8%)	0.33
Polymicrobial infections	3 (3.1%)	8 (10.3%)	15 (11.7%)	0.35
Most preferred initial antibiotic regimen	Combination of two regimens 29 (30.5%)	Combination of two regimens 34 (44.1%)	Quinolone 45 (35.1%)	0.057
Failure rate of first line antibiotherapy	25 (26.3%)	30 (38.9%)	39 (30.4%)	0.39
Chronic parenchymal lung disease[2]	37 (38.9%)	32 (41.5%)	64 (50%)	0.27
Using systemic steroid[3]	35 (36.8%)	50 (63.6%)	69 (53.9%)	**0.002**
Systemic chemotherapy[4]	51 (50.4%)	33 (32.6%)	17 (16.8%)	**<0.001**

1: NSCLC: Non-small cell lung cancer, **SCLC:** Small cell lung cancer
2: Existence of any of chronic obstructive pulmonary disease, interstitial lung disease and bronchiectasis
3: Usage Dexamethasone or metil-prednisolone
4: Palliative (n=76) and adjuvant (n=6) chemotherapy, chemo-radiotherapy (n=19)

considered that, the more effective treatment of COPD means lower incidence of exacerbations and an uninterrupted treatment process of malignancy.

There are several studies that delineating the pathogen profile that microbiologically documented. In a study which included 275 patients who examined infections in lung cancer cases, tracheobronchial tree was predominant site of infection. The most frequent pathogens were gram-negative bacteria (Haemophilus influenza, Moraxella catarrhalis) following gram positive bacteria [5]. In a study with 205 geriatric lung cancer patients, gram negative pathogens were found more frequently [10]. The presence of febrile neutropenia is also an important risk factor for gram negative isolation mostly haemophilus influenza, pseudomonas aeruginosa [11]. The most isolated pathogens were also gram negative (pseudomonas aeruginosa, acinetobacter baumannii, enterobacteriaceae) in our study. These results show that nowadays, mortal infections are more common, and the antibiotic regimens chosen in the first stage should be paid attention. In fact, when we look at physician attitudes in our study data, the rate of onset with dual antibiotic treatment is quite high. Probably, therefore the antibiotic failure rate is as high as 35.7%. Also there were 26 (8.7%) patients with polymicrobial infections. This can be explained by the presence of hospital-acquired secondary infections or the presence of amplified strains that are resistant to initial antibiotic therapy.

In patients with lung cancer, bacterial opportunistic infections as well as fungal infections are more common in tracheobronchial tree due to palliative or curative thoracic radiotherapy. Mucosal injury due to RT causes severe esophagitis accompanied by candida superinfection. Empiric antifungal therapy should be initiated when candida infection from the oropharyngeal mucosa is considered. Development of candidiasis is facilitated by usage of steroids [12]. In our study, there was no isolated candida infection, and it was seen together with bacterial infection in all cases (n=35, 28.9%). Parenteral antifungal therapy was initiated in only 8 patients due to lack of response to prior antibiotic therapy. In this study, we did not examine the relationship between radiotherapy and candida infection. However, we think that steroid use

(inhaler / parenteral) poses a risk for candida as well as bacterial infections. It is known that adequate oral care reduces the incidence of pneumonia [13]. Therefore, especially in patients with COPD, oral care is given together with inhaler treatment and local nystatin treatment is initiated in patients with plaque appearing in the oral mucosa.

A study including fatal pulmonary infections in SCLC patients including an autopsy examination revealed fatal infection in 39 cases. Among these pathogens, fungal, pneumocystis carinii (PC), tuberculosis as well as bacterial factors were detected in 8 cases. The cumulative dose of steroids was found to be significantly higher in patients who died due to fungal causes compared to bacteria and other factors [7]. Similarly, according to an autopsy data with 304 lung cancer patients, the use of steroids in combination with chemotherapy significantly increased the risk of pulmonary mycobacterial infection compared to chemotherapy alone (10.5% vs 2.6%, P =0.028) [14]. In our study, 50 (63.6%) of 77 patients whose treatment was terminated were taking systemic steroids and steroid usage rate was higher than the other two groups (p=0.002) (delayed or unaffected).

It is known that chemotherapy alone is a risk factor for pneumonia. However, there is a lack of data about the effect of lower respiratory tract infections on the treatment of lung cancer as it constitutes our main end point. According to a study including 84 lung cancer patients (mostly locally advanced and advanced stage patients) with pneumonia following chemotherapy, pneumonia treatment failed in 28 patients. Although the presence of tachypnoea alone was associated with the failure of pneumonia treatment, the most important point was the death of 28 (33%) cases due to pneumonia [15]. In our study, it is a valuable data to show that pneumonia developed after chemotherapy causes failure in the treatment of malignancy unlike all treatment modalities. Prior to beginning cytotoxic therapy, it is critical to assess the patient's performance, nutritional state, social support, and co-morbidities.

Limitations

One of reason to effect power of study is due to retrospective nature it was not possible to grouping patients according to initial antibiotic regimen, dose and duration of steroids. So, stronger predictive result about reason for failure of antibiotic choice could have been achieved. The other issue may be considered is lack of knowledge about extension and degree of chronic parenchymal lung disease radiological. Because it should be an important determinant for a lung cancer patient.

Conclusion

Although progress has been made in the diagnosis and treatment of lung cancer, patients are prone to developing infectious complications. Pulmonary infections remain an important cause of morbidity and mortality in lung cancer patients receiving chemotherapy. Recognition of risk factors should guide the clinician in performing the appropriate diagnostics and in selecting antimicrobial therapy.

Author contribution statement

All authors (PAK and ÜY) participated in the planning, writing, editing, and review of this manuscript.

Conflicts of interest and funding

None of authors have financial support or grant for this study.

Ethical approval

The study was approved by the Ethics Committee of the Atatürk Chest Disease and Thoracic Surgery Teaching and Research Hospital with number of 579 - 21.11.2017.

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References

1. Seo SK. Infectious Complications of Lung Cancer. Oncology (Williston Park). 2005 Feb;19(2):185-94
2. Putinati S, Trevisani L, Gualandi M, et al: Pulmonary infections in lung cancer patients at diagnosis. Lung Cancer 11:243-249, 1994.
3. Perlin E, Bang KM, Shah A, et al: The impact of pulmonary infections on the survival of lung cancer patients. Cancer 66:593-596, 1990.
4. Kohno S, Koga H, Oka M, et al: The pattern of respiratory infection in patients with lung cancer. Tohoku J Exp Med 173:405-411, 1994.
5. Berghmans T, Sculier JP, Klastersky J: A prospective study of infections in lung cancer patients admitted to the hospital. Chest 124:114- 120, 2003.
6. Nichols L, Saunders R, Knollmann FD. Causes of Death of Patients with Lung Cancer. Arch Pathol Lab Med. 2012; 136:1552–1557.
7. Remiszewski P, Słodkowska J, Wiatr E, Zych J, Radomski P, Rowińska-Zakrzewska E. Fatal infection in patients treated for small cell lung cancer in the Institute of Tuberculosis and Chest Diseases in the years 1980-1994. Lung Cancer. 2001 Feb-Mar;31(2-3):101-10.

8. Höffken G, Lorenz J, Kern W, et al; Paul-Ehrlich-Gesellschaft für Chemotherapie; Deutschen Gesellschaft für Pneumologie und Beatmungsmedizin; Deutschen Gesellschaft für Infektiologie und vom Kompetenznetzwerk CAPNETZ. Epidemiology, diagnosis, antimicrobial therapy and management of community-acquired pneumonia and lower respiratory tract infections in adults. Guidelines of the Paul-Ehrlich-Society for Chemotherapy, the GermanRespiratory Society, the German Society for Infectiology and theCompetence Network CAPNETZ Germany [in German]. Pneumologie 2009;63(10):e1–e68
9. Rikimaru T, Ichiki M, Ookubo Y, Matumoto K, Mimori Y, Sueyasu Y et al. Prognostic significance of febrile episodes in lung cancer patients receiving chemotherapy. Support Care Cancer. 1998 Jul;6(4):396401.
10. Kobashi Y, Okimoto N, Matsushima T. Pneumonia associated with lung cancer in the elderly. Kansenshogaku Zasshi. 2002 Mar;76(3):18894.
11. Lanoix JP, Pluquet E, Lescure FX, Bentayeb H, Lecuyer E, Boutemy M et al. Bacterial infection profiles in lung cancer patients with febrile neutropenia. BMC Infect Dis. 2011 Jun 27;11:183. doi: 10.1186/1471-2334-11-183.
12. Nagata N, Nikaido Y, Kido M, Ishibashi T, Sueishi K. Terminal pulmonary infections in patients with lung cancer. Chest 103:1739-1742, 1993.
13. Akinosoglou KS, Karkoulias K, Marangos M. Infectious complications in patients with lung cancer. Eur Rev Med Pharmacol Sci. 2013 Jan;17(1):8-18.
14. Iwata E, Hasegawa T, Yamada SI, Kawashita Y, Yoshimatsu M, Mizutani T et al. Effects of perioperative oral care on prevention of postoperative pneumonia after lung resection: Multicenter retrospective study with propensity score matching analysis. Surgery. 2019 May;165(5):1003-1007. doi: 10.1016/j.surg.2018.11.020. Epub 2019 Feb 11.
15. Yoo SS, Cha S, Shin KM, Lee SY, Kim CH, Park JY et al. Bacterial pneumonia following cytotoxic chemotherapy for lung cancer: clinical features, treatment outcome and prognostic factors. Scand J Infect Dis. 2010 Oct;42(10):734-40. doi: 10.3109/00365548.2010.489569.

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Original Article

Correlation of Perfusion Indices with Disease Severity in COVID-19 Patients

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Abstract

Background: In this study, we aimed to evaluate the correlation of perfusion indexes with disease severity in COVID-19 patients.

Methods: Our study was conducted as a prospective observational study after obtaining ethical committee approval. Patients over the age of 18, who presented with COVID-19 symptoms, were PCR (Polymerase Chain Reaction) positive, were included in the study. Demographic data, complaints, vital signs and laboratory values of the patients were recorded. The perfusion index (PI) and plethysmographic variability index (PVI) were measured. Patients were divided into two groups according to disease severity: mild, moderate and severe.

Results: A total of 154 patients were included in the study. 47.4% of the patients included in the study were male, and the median age of 57 (interquartile range [IQR] 44-69.2). 33.1% of the patients were in the mild group, and 66.9% in the moderate-severe group. The median PI value was 4.2 (IQR 3.1-5.6) and the median PVI value was 14.2 (IQR 11.5-16.5) in the mild-moderate patient group, the median PI value was 1.54 (IQR 1.14-1.97), the median PVI value was 23.4 (IQR 11.5-16.5) in the moderate-severe patient group. IQR 19.8-26.1) ($p<0.05$ for all parameters). The area under the curve AUC for PVI was 0.928 (95% CI; 0.887-0.969 $p<0.001$). When the best cut-off value of the PVI was taken as 16.3 to distinguish patients from the moderate-severe group, the sensitivity and specificity were calculated as 95% and 71% for this value. The AUC for PI was 0.895 (95% CI; 0.844-0.946, $p<0.001$). When the best cut-off value of the perfusion indices was taken as 1.76 to distinguish patients with mild to moderate severity, the sensitivity was calculated as 94% and the specificity as 70.9%.

Conclusions: We found that PVI levels were associated with mean arterial pressure, shock index, lactate and base deficit levels, especially saturation. We think that the cut-off value of high PVI and low PI levels in differentiating severe disease, with its high sensitivity and specificity, may be clinically useful in predicting patients with severe COVID-19 pneumonia.

Keywords
COVID-19, perfusion indices, PI, PVI

Introduction

Coronavirus Disease 2019 (COVID-19) infection can present with clinical symptoms ranging from asymptomatic to mild, resembling upper respiratory tract infections, but it can also lead to severe viral pneumonia, resulting in respiratory failure and death [1-3]. Detection of viral RNA through real-time reverse transcriptase polymerase chain reaction (RT-PCR) from nasal or throat swabs or respiratory samples is considered the gold standard diagnostic method [4].

COVID-19 manifestations can range from mild to severe. Patients requiring hospitalization can present with advanced pneumonia, acute respiratory distress syndrome (ARDS), sepsis, myocarditis, arrhythmias, cardiogenic shock, metabolic acidosis, coagulopathy, and multi-organ failure [5]. With the increased number of hospital admissions, it is crucial to manage this disease more rapidly in emergency departments. Therefore, determining the severity of COVID-19 infection is essential for acute treatment management in the emergency department and for deciding which cases need hospitalization or intensive care unit (ICU) monitoring. Perfusion indices provide useful, quantitative data for rapid

assessment of patient hemodynamic in emergency departments and intensive care units [6-8].

In many studies, changes in perfusion indices in ICU, operating rooms, and emergency departments have been suggested as a simple and non-invasive method to monitor perfusion, response to treatment, and disease severity (6, 8). Changes in perfusion indices have been identified in many critically ill COVID-19 patients, showing typical shock clinical signs [9]. Many of these patients showed severe metabolic acidosis, indicating possible microcirculatory dysfunction [10]. According to the Sepsis-3 International Consensus, these patients met the diagnostic criteria for sepsis and septic shock, with SARS-CoV-2 infection being the primary cause in most of them [11]. In severe COVID-19 infection, direct viral attack on organs, systemic cytokine storms causing immune pathogenesis, and microcirculatory dysfunction may lead to viral sepsis, septic shock, and ultimately hypoperfusion across all systems [9]. Also, COVID-19 worsens rapidly in some patients, making it important to find early markers for predicting these deteriorating patients [12].

Perfusion Index (PI) represents the real-time and continuous perfusion status of a specific area during a specific time interval. The Plethysmographic Variability Index (PVI) is a dynamic measure of PI variation, reflecting the pulse oximeter waveform amplitude, occurring during one or more complete respiratory cycles. PVIs are calculated using maximum and minimum PI values obtained during the respiratory period [6, 8]. Many studies have suggested that changes in perfusion indices in intensive care units, operating rooms, and emergency departments are easy to apply and non-invasive methods for monitoring perfusion, treatment response, and disease severity. Studies have shown that low PI and high PVI values are objective and meaningful indicators of acute disease and mortality in intensive care units and emergency departments [6, 8].

Our study aimed to evaluate the correlation between perfusion indices, disease severity, and perfusion markers (vital signs and lactate) in COVID-19 patients.

Materials and Methods

Study design and participants

This is a prospective, observational study approved by the Local Ethics Committee (2012-KAEK-15/2412).

Patients aged 18 and above who presented to the emergency medicine clinic with COVID-19 symptoms between August 2021 and February 2022 and had a PCR-positive result were included in the study. Patients with missing data, those who refused to participate, those with peripheral vascular disease, pregnant women, and patients under 18 were excluded.

Data collection

Demographic data, complaints, vital signs, and laboratory values of eligible patients were recorded. Simultaneously, PI and PVI measurements were made while recording vital signs. Diagnosis, follow-up, and treatment were conducted according to the Ministry of Health of the Republic of Turkey's COVID-19 guidelines. According to the Ministry of Health's COVID-19 adult patient guidelines, the patients were divided into mild-moderate and severe groups based on the severity of the disease. The mild-moderate group included:

- Uncomplicated patients: Patients with symptoms such as fever, muscle/joint pain, cough, and sore throat but without respiratory distress (respiratory rate <24 breaths/min and SpO2 >93% in room air), with normal chest radiography and/or CT.
- Mild-moderate pneumonia patients: Patients presenting with fever, cough, muscle/joint pain, and sore throat, with respiratory rate <30 breaths/min, SpO2 ≥90% in room air, and mild-moderate pneumonia findings (bilateral or unilateral <50% infiltration) on chest radiography or CT.

The severe group included patients with fever, muscle/joint pain, cough, and sore throat, with respiratory rate >30 breaths/min, SpO2 ≤89% in room air, and bilateral extensive pneumonia findings (infiltration >50%) on chest radiography or CT.
The outcome of the study was determined as disease severity.

Measurement of PI and PVI

PI and PVI were measured at the time of the patient's initial presentation to the emergency department, using the Masimo Radical 7 monitor's pulse oximeter sensor. The measurement was taken after the patient was positioned on a stretcher with their back supported, legs extended, and using the fourth finger of their non-dominant hand. Values were recorded after stabilization on the device and a 5-minute wait.

Sample Size

A 2% change in PI between COVID-19 groups (mild-moderate and severe) was considered a clinically significant change. The sample size was calculated as 146 participants, with a type 1 error rate of 5%, a type 2 error rate of 5%, and a power of 95%. The standard deviations for PI values from previous studies were assumed to be 2.9% and 4.1% [12].

Statistical Analysis

All data were analysed using IBM SPSS 20.0 (Chicago, IL, USA). The normality of the distribution of continuous variables was tested using the Kolmogorov-Smirnov test. Descriptive statistics for continuous variables were presented as median [interquartile range (IQR)], and categorical variables were presented as count and percentage. Categorical variables were evaluated using the Chi-square test, while continuous variables were assessed using the Mann-Whitney U test. Receiver operating characteristic (ROC) analysis was performed to evaluate the correlation parameters of PI and PVI values, and the area under the curve (AUC) values were calculated to differentiate between surviving and deceased patients. Results were considered statistically significant when $p<0.05$.

Results

Data from 397 patients were reviewed during the study. 133 patients were excluded due to negative PCR tests, 71 patients refused to participate, 7 patients were admitted to the intensive care unit without completing tests in the emergency department, and 32 patients were excluded due to missing data. A total of 154 patients were included in the study **(Figure-1).** Of the patients included in the study, 47.4% were male (n=73), with a median age of 57 (IQR 44-69.2). The median perfusion indices for the patients were: PI 1.78 (IQR 1.32-3.70) and PVI 20.4 (15.6-24.5). Demographic data and perfusion index values for all patients are presented in **Table 1.**

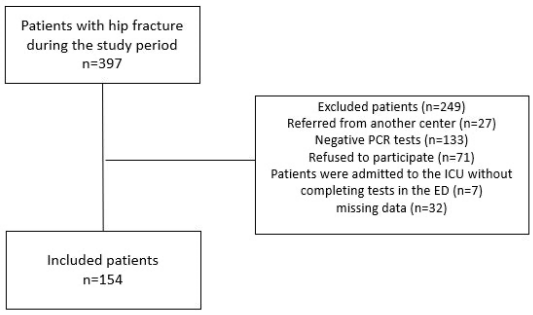

Figure 1: Flowchart showing number of patients of the study

When comparing groups based on disease severity, it was found that most patients in the severe group were male, with a higher median age, more frequent chronic kidney disease, higher systolic and diastolic blood pressure values, respiratory rate, pulse, mean arterial pressure, shock index, and PVI. In contrast, saturation values and PI were lower in the severe group (all p-values <0.05) **(Table 2).**

Table 1: Demographic Data of Patients (n=154)

Age, median (IQR 25 -75)	57(44-69.2)
Gender, n (%)	
▪ Male	73 (47.4%)
▪ Female	81 (52.6%)
Comorbidity, n (%)	
▪ Hypertension	78 (50.6%)
▪ Coronary Artery Disease	41 (26.6%)
▪ Congestive Heart Failure	11 (7.1%)
▪ Chronic Obstructive Pulmonary Disease	9 (5.8%)
▪ Chronic Kidney Disease	18 (11.7%)
▪ Diabetes mellitus	34 (22.1%)
Symptom, n (%)	
▪ Fever	102 (66.2%)
▪ Cough	82 (53.2%)
▪ Dyspnea	68 (44.2%)
▪ Diarrhea	38 (24.7%)
▪ Weakness/Myalgia	93 (60.4%)
▪ Loss of Smell and Taste	47(30.5%)
Vital Signs, median (IQR 25 -75)	
▪ Fever	37.9 (37.2-38.3)
▪ Pulse	104.5 (84.7-117)
▪ Saturation	93 (90-95)
▪ Systolic Blood Pressure	125 (114-137)
▪ Diastolic Blood Pressure	85 (77-96)
▪ GKS	15 (15-15)
▪ MAP	97.3 (90.5-110.3)
▪ Shock Index	0.77 (0.67-0.93)
Perfusion Indices, median (IQR 25 -75)	
▪ PVI	20.4 (15.6-24.5)
▪ PI	1.78 (1.32-3.70)
COVID Severity, n (%)	
▪ Mild-moderate	51 (33.1%)
▪ Severe	103 (66.9%)
Outcome, n (%)	
▪ Outpatient Treatment-Discharge	20 (13%)
▪ Service Admission	102 (66.2%)
▪ Admission to Intensive Care Unit	32 (20.8%)

GKS: Glasgow Coma Score, MAP: Mean Arterial Pressure, PI: Perfusion Index, PVI: Plethysmographic Variability Index

Table 2: Comparison of Demographic Characteristics of Patients with Mild-Moderate Severity and Patients with Severe Severity

	Mild-Moderate (n=51)	Severe (n=103)	P value
Age, median (IQR 25-75)	56 (37-64)	60 (44-71)	0.035
Gender, n (%)			
▪ Male	23 (45.1%)	58 (56.3%)	0.021
▪ Female	28 (54.9%)	45 (43.7%)	0.190
Comorbidities, n (%)			
▪ Hypertension	23 (45.1%)	55 (53.4%)	0.332
▪ Coronary Artery Disease	9 (17.6%)	32 (31.1%)	0.076
▪ Congestive Heart Failure	1 (2%)	10 (9.7%)	0.102
▪ Chronic Kidney Disease	2 (3.9%)	16 (15.5%)	0.035
▪ Diabetes mellitus	11 (21.6%)	23 (22.3%)	0.915
▪ Chronic Obstructive Pulmonary Disease	1 (2%)	11 (7.8%)	0.273
Vital signs, median (IQR 25-75)			
▪ Systolic Blood Pressure	121 (114-132)	128(115-139)	0.016
▪ Diastolic Blood Pressure	82 (77-88)	87 (78-98)	0.010
▪ Respiratory Rate	14 (13-15)	16 (14-19)	<0.001
▪ Pulse	88 (77-105)	111 (91-123)	<0.001
▪ Fever	37.8 (37.1-38.1)	37.9 (37.2-38.4)	0.062
▪ Saturation	96 (95-96)	91 (88-93)	<0.001
▪ GKS	15 (15-15)	15 (15-15)	0.811
▪ MAP	94 (90-100.3)	100.6 (91.6 - 111.6)	0.010
▪ Shock Index	0.72 (0.63-0.82)	0.82 (0.71-0.96)	<0.001
Perfusion indices, median (IQR 25-75)			
▪ PVI	14.2 (11.5-16.5)	23.4 (19.8-26.1)	<0.001
▪ PI	4.2 (3.1-5.6)	1.54 (1.14-1.97)	<0.001

GKS: Glasgow Coma Score, MAP: Mean Arterial Pressure, PI: Perfusion Index, PVI: Plethysmographic Variability Index

The correlation coefficients and significance levels between PVI and perfusion markers such as saturation, shock index, MAP, BE, and lactate levels were analyzed. In the severe patient group, a statistically significant, inverse, and strong correlation between PVI and saturation was found (r= -0.857, p<0.001). A statistically significant, direct, weak correlation was found between PI and both BE and lactate (r = 0.599, p < 0.001; r = 0.456, p < 0.001, respectively). In the severe group, a statistically significant, direct, and strong correlation between PI and saturation was found (r =0.721, p<0.001). Additionally, a statistically significant, inverse, weak correlation was observed between PVI and both BE and lactate (r = –0.480, p<0.001; r = –0.470, p<0.001, respectively) **(Table 3).**

Table 3: Correlation of Perfusion Indices (PI and PVI) with Perfusion Markers in the Severe Patient Group

	PI Correlation coefficient	p-value	PVI Correlation coefficient	p-value
Saturation	0.721	<0.001	-0.820	<0.001
Shock Index	-0.229	0.020	0.347	<0.001
MAP	-0.193	0.051	-0.059	0.552
BE	-0.480	<0.001	0.599	<0.001
Lactate	-0.470	<0.001	0.456	<0.001

BE: Base excess; MAP: Mean Arterial Pressure

ROC analysis was conducted to determine the threshold values for perfusion indices between the mild-moderate and severe patient groups, and the AUC was calculated. The AUC value for PVI was 0.928 (95% CI: 0.887-0.969, p<0.001). When the threshold value for PVI to distinguish severe patients was set at 16.3, the sensitivity and specificity were calculated to be 95% and 71%, respectively (table 4). The AUC for PI was 0.895 (95% CI: 0.844-0.946, p < 0.001), and when the threshold value for PI to distinguish severe patients was set at 1.76, the sensitivity and specificity were 70.9% and 94% respectively **(Table 4).**

Table 4: Diagnostic Performance of Perfusion Indices (PI and PVI)

Index	PVI	PI
AUC (95% CI)	0.928 (0.887–0.969)	0.105 (0.054-0.156)
Cut-off	16.3	1.76
Sensitivity (%)	95.1 (89%-98%)	70.8 (61%-79%)
Specificity (%)	70.6 (56%-82%)	94.1 (84%-98%)
PPV (%)	86.3% (81%-91)	96% (89%-98%)
NPV (%)	87.8 (75%-94%)	61.5% (54%-68%)
PLR	3.23 (2.11 (4.95)	12.05 (3.99-36.3)
NLR	0.07 (0.03-0.17)	0.31 (0.23-0.42)
Accuracy (%)	87% (80.6%-92%)	78.5% (71%-85%)

AUC: Area under curve, PPV: Positive Predictive Value, NPV: Negative Predictive Value, PLR: Positive likelihood ratio, NLR: Negative likelihood ratio

Discussion

Determining the severity of COVID-19 infection is crucial for acute treatment management in the emergency department and for handling critical cases. Like vital signs, perfusion indices (PI and PVI) used in monitoring the general condition of patients can provide emergency physicians with highly useful data for assessing hemodynamic and making clinical decisions. COVID-19 is a viral disease that affects multiple organ systems and can rapidly deteriorate the patient's perfusion. In this study, which evaluates the correlation between perfusion indices and disease severity in COVID-19 patients, we believe there are two significant findings.

Firstly, we found that high PVI and low PI levels measured at the time of emergency department admission were significantly higher in severe COVID-19 patients compared to those in the mild-to-moderate group. We believe that these high PVI and low PI levels, with high sensitivity and specificity, could be clinically useful in distinguishing severe COVID-19 cases and predicting the progression of the disease.

Secondly, we found that PVI levels, especially saturation, were strongly correlated with other perfusion markers, including vital signs. One of the most important clinical challenges for physicians in managing severe COVID-19 patients is the early identification of these patients and determining the need for intensive care. Non-invasive perfusion indices, easily measured at the bedside, can help rapidly identify critically ill COVID-19 patients and assess the severity of the disease, especially in emergency departments with high patient volumes.

COVID-19 is a disease that can affect all organ systems, particularly the respiratory system [2]. During periods of increased COVID-19 cases worldwide, determining the need for hospitalization or ICU admission becomes critical due to limited healthcare resources. Early recognition of severe forms of the disease has relied on various clinical factors, including the patient's clinical status, oxygen levels, comorbidities, and several laboratory values [9]. Research continues on the role of changes in vital signs such as pulse, blood pressure, and saturation in predicting the progression of COVID-19 disease [14]. In COVID-19 patients, when oxygen saturation is assessed alongside respiratory rate, it has been found to be associated with the need for mechanical ventilation and poor outcomes [15].

In our study, we also found that the severe group had lower saturation values and increased respiratory rate. Blood pressure regulation is important in both acute and chronic diseases, including COVID-19. A meta-analysis by Mutadsir et al. found that severe COVID-19 was associated with high systolic blood pressure [16]. Similarly, a study by Ran et al. found that poor blood pressure control was linked to adverse COVID-19 outcomes [17]. In our study, systolic and diastolic blood pressure values were significantly higher in the severe group. A review of previous studies has shown that acidosis and hyperlactatemia may be associated with severe COVID-19 [18]. Many critically ill COVID-19 patients have been found to develop typical shock clinical signs, including cold extremities and weak peripheral pulses, even in the absence of severe hypotension [9]. Most of these patients exhibited severe metabolic acidosis, which suggests possible microcirculatory dysfunction. Furthermore, some patients with severe lung damage have also presented with liver and kidney dysfunction [10, 19]. These patients meet the diagnostic criteria for sepsis and septic shock according to the Sepsis-3 International Consensus, with SARS-CoV-2 infection being the primary cause in most of them. In uncontrolled coronavirus infection, alveolar macrophages or epithelial cells produce various pro-inflammatory cytokines and chemokines, leading to macrophage infiltration, significant lymphocyte depletion, functional impairment, and worsening lung damage. At the same time, the spreading SARS-CoV-2 virus directly attacks other organs, causing immune pathogenesis due to systemic cytokine storms and microcirculatory disturbances, ultimately leading to viral sepsis and hypoperfusion across all organ systems [9].

Additionally, PI derived from pulse oximeter signals has been shown to be an accurate predictor of high disease severity [20]. Another study, which included 113 patients followed for sepsis in the ICU, indicated that non-invasive monitoring with PVI values guided hypotension treatment, and high PVI values correlated with lactate and mean arterial pressure, thus directing treatment management [21]. In our study, we demonstrated that in the severe patient group, PI and PVI correlate with vital signs and lactate, particularly saturation. However, we did not find a relationship between MAP and either PI or PVI. Nonetheless, we believe that perfusion indices, measured frequently using a simple finger probe without the development of hypotension, could aid in the early identification and monitoring of critically ill patients in crowded emergency department triage settings. Lactate measurement, however, is invasive and time-consuming. In contrast, simple and rapid perfusion indices, measured during triage at the time of emergency department admission, could facilitate the early identification of critically ill COVID-19 patients in a short period.

Our study was designed as a single-center study, and therefore, the results cannot be generalized to all centers. Secondly, according to the Ministry of Health of the Republic of Turkey's adult patient guidelines, patient admissions, tests, and treatments have varied to some extent during the pandemic. Thirdly, the measurement of PI and PVI may yield different results in patients with spontaneous respiration. These factors may have influenced our results. Regression analysis could not be performed because the number of our patients was not large enough for regression analysis. Finally, as our study started in the emergency department and ended in different locations such as inpatient wards and intensive care units, sequential PI and PVI measurements could not be performed.

Conclusion

We believe that perfusion indices will be useful for emergency physicians in rapidly assessing the hemodynamic of COVID-19 patients and adjusting their treatment accordingly. High PVI and low PI levels can be used with high sensitivity and specificity to distinguish severe cases and predict patient outcomes in emergency department practice. We found that PVI levels, particularly saturation, were strongly correlated with other vital perfusion markers. The use of fast and easily measurable PI and PVI values will positively impact clinical applications for early triage and diagnosis.

Author contribution statement

All authors (EY, EE, YÇ) participated in the planning, writing, editing, and review of this manuscript.

Conflicts of interest

None Declared.

Ethical approval

Ethical approval for this study was obtained from Atatürk Sanatoryum Training and Research Hospital Ethics Committee (2012-KAEK-15/2412, 12.08.2021)

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References

1. Cui X, Zhao Z, Tongqiang Z, et al. A systematic review and meta-analysis of children with Coronavirus Disease 2019 (COVID-19). J Med Virol. 2021 Feb;93(2):1057-1069. doi: 10.1002/jmv.26398
2. Alsharif W, Qurashi A. Effectiveness of COVID-19 diagnosis and management tools: A review. Radiography (Lond). 2021;27(2):682-687. doi: 10.1016/j.radi.2020.09.010
3. Umakanthan S, Sahu P, Ranade AV, et al. Origin, transmission, diagnosis and management of coronavirus disease 2019 (COVID-19). Postgrad Med J. 2020;96(1142):753-758 doi: 10.1136/postgradmedj-2020-138234
4. Dramé M, Tabue Teguo M, Proye E, et al. Should RT-PCR be considered a gold standard in the diagnosis of COVID-19? J Med Virol. 2020;92(11):2312-2313. doi: 10.1002/jmv.25996
5. Böger B, Fachi MM, Vilhena RO, Cobre AF, Tonin FS, Pontarolo R. Systematic review with meta-analysis of the accuracy of diagnostic tests for COVID-19. Am J Infect Control. 2021;49(1):21-9. doi: 10.1016/j.ajic.2020.07.011
6. Kaneda T, Suzuki T. [Evaluation of circulatory state using pulse oximeter: 2. PI (perfusion index) x PVI (pleth variability index)]. Masui. 2009;58(7):860-5.
7. Öztekin Ö, Emektar E, Selvi H, Çevik Y. Perfusion indices can predict early volume depletion in a blood donor model. Eur J Trauma Emerg Surg. 2022 Feb;48(1):553-557. doi: 10.1007/s00068-020-01463-5
8. Broch O, Bein B, Gruenewald M, et al. Accuracy of the pleth variability index to predict fluid responsiveness depends on the perfusion index. Acta Anaesthesiol Scand. 2011;55(6):686-93. doi: 10.1111/j.1399-6576.2011.02435.x
9. Li H, Liu L, Zhang D, Xu J, et al. SARS-CoV-2 and viral sepsis: observations and hypotheses. Lancet. 2020;395(10235):1517-1520 doi: 10.1016/S0140-6736(20)30920-X
10. Zhang C, Shi L, Wang FS. Liver injury in COVID-19: management and challenges. Lancet Gastroenterol Hepatol. 2020;5(5):428-430. doi: 10.1016/S2468-1253(20)30057-1
11. Guan WJ, Ni ZY, Hu Y, et al. China Medical Treatment Expert Group for Covid-19. Clinical Characteristics of Coronavirus Disease 2019 in China. N Engl J Med. 2020;382(18):1708-1720. doi: 10.1056/NEJMoa2002032
12. Merad M, Blish CA, Sallusto F, Iwasaki A. The immunology and immunopathology of COVID-19. Science. 2022;375(6585):1122-1127 doi: 10.1126/science.abm8108
13. Keller G, Cassar E, Desebbe O, Lehot JJ, Cannesson M. Ability of pleth variability index to detect hemodynamic changes induced by passive leg raising in spontaneously breathing volunteers. Crit Care. 2008;12(2):R37. doi: 10.1186/cc6822
14. Manta C, Jain SS, Coravos A, Mendelsohn D, Izmailova ES. An Evaluation of Biometric Monitoring Technologies for Vital Signs in the Era of COVID-19. Clinical and Translational Science. 2020;13(6):1034-44. doi: 10.1111/cts.12874
15. Wang Z, Yang B, Li Q, Wen L, Zhang R. Clinical Features of 69 Cases With Coronavirus Disease 2019 in Wuhan, China. Clinical Infectious Diseases. 2020;71(15):769-77. doi: 10.1093/cid/ciaa272
16. Mudatsir M, Fajar JK, Wulandari L, et al. Predictors of COVID-19 severity: a systematic review and meta-analysis. F1000Res. 2020;9:1107 doi: 10.12688/f1000research.26186.2
17. Ran J, Song Y, Zhuang Z, Han L, et al. Blood pressure control and adverse outcomes of COVID-19 infection in patients with concomitant hypertension in Wuhan, China. Hypertens Res. 2020;43(11):1267-76. doi: 10.1038/s41440-020-00541-w
18. Nechipurenko YD, Semyonov DA, Lavrinenko IA, et al. The Role of Acidosis in the Pathogenesis of Severe Forms of COVID-19. Biology. 2021;10(9):852. doi: 10.3390/biology10090852
19. Sarıaydın T, Çorbacıoğlu ŞK, Çevik Y, Emektar E. Effect of initial lactate level on short-term survival in patients with out-of-hospital cardiac arrest. Turk J Emerg Med. 2017;17(4):123-127. doi: 10.1016/j.tjem.2017.05.003
20. De Felice C, Latini G, Vacca P, Kopotic RJ. The pulse oximeter perfusion index as a predictor for high illness severity in neonates. Eur J Pediatr. 2002 Oct;161(10):561-2 doi: 10.1007/s00431-002-1042-5
21. Forget P, Lois F, de Kock M. Goal-directed fluid management based on the pulse oximeter-derived pleth variability index reduces lactate levels and improves fluid management. Anesth Analg. 2010;111(4):910-4. doi: 10.1213/ANE.0b013e3181eb624f

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Investigation of Emergency Physicians' Compliance with Computed Tomography Rules in Pediatric Patients with Head Trauma

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Abstract

Objective: Pediatric head trauma is among the leading causes of emergency department (ED) admissions. The Pediatric Emergency Care Applied Research Network (PECARN) clinical decision rule is a validated tool developed to minimize unnecessary computed tomography (CT) scans while accurately identifying traumatic brain injuries (TBIs). This study aims to assess emergency physicians' adherence to PECARN guidelines and explore the factors influencing their CT imaging decisions.

Methods: A multicenter survey was administered to emergency medicine specialists, residents, and general practitioners working in EDs that received pediatric trauma patients between January 2021 and January 2023. The questionnaire was based on PECARN criteria and employed a Likert-scale format. Demographic characteristics and clinical experience of participants were also collected and analyzed.

Results: A total of 202 physicians participated in the survey. While 32% reported adherence to the PECARN algorithm, objective evaluation revealed lower actual compliance. The most significant factor influencing CT imaging decisions was altered mental status. Additionally, fear of malpractice and parental insistence were notable contributors. Physicians practicing in tertiary care hospitals demonstrated higher adherence rates.

Conclusions: The PECARN algorithm is underutilized in clinical settings. Enhancing compliance may require targeted physician training, nationwide standardization initiatives, and institutional protocols. It is also essential to address underlying issues such as medicolegal concerns and parental expectations to promote appropriate imaging practices.

Keywords
Pediatric Head Trauma, PECARN, Emergency Medicine, Computed Tomography, Clinical Decision Rules

Introduction

The majority of pediatric patients admitted to emrgency departments (EDs) for head trauma have minor injuries, typically with a Glasgow Coma Scale score above 13 [1]. Within this subgroup, less than 10% are found to have traumatic brain injury (TBI), and fewer than 1% require neurosurgical intervention [2, 3].

Surveillance data from the United States Centers for Disease Control and Prevention indicate that approximately 475,000 children aged 0–14 years sustain TBI annually. Most of these cases involve mild injuries that do not necessitate inpatient care, while an estimated 37,000 children are hospitalized, and around 2,700 succumb to their injuries [4].

Cranial computed tomography (CT) remains the most frequently employed imaging modality in the assessment of children with minor head trauma. However, due to the potential long-term risks of ionizing radiation in pediatric populations, its use warrants caution. In a single-center study, the rate of CT utilization among pediatric patients with minor head injury increased from 10.6% per 1,000 patients in 1999 to 21.5% in 2010 [5]. The estimated risk of radiation-induced fatal malignancy from cranial CT in children ranges from 1 in 1,000 to 1 in 5,000 [6–8].

To minimize unnecessary CT imaging while maintaining diagnostic safety, numerous clinical decision rules have been developed [9]. Among the most extensively validated is the Pediatric Emergency Care Applied Research Network (PECARN) rule, established through a large multicenter study involving 42.212 children with GCS scores of 14–15 who presented within 24 hours of blunt head trauma.

The algorithm stratifies patients into two age groups—under two years and two years or older—with distinct CT indications for each. PECARN demonstrated a sensitivity and negative predictive value of 100% for identifying clinically significant TBIs.

In this study, we aim to evaluate the factors influencing CT ordering behavior in pediatric head trauma cases and to assess the adherence of emergency physicians to established clinical decision-making algorithms, particularly the PECARN rule, through a multicenter survey-based approach.

Materials and Methods

Study design and participants

This cross-sectional, observational study was conducted between January 2021 and January 2023. The study population consisted of emergency medicine specialists, emergency medicine residents, and general practitioners who worked in EDs where pediatric trauma patients were evaluated during the study period. The survey form used for data collection and the responses are presented in **Annex-1 and 2**.

Demographic information including age, gender, years of clinical experience, and the type of hospital (secondary or tertiary care) in which the participants worked was recorded. Physicians' approaches to evaluating pediatric head trauma patients were assessed based on their responses to Likert-scale questions developed in accordance with the PECARN (Pediatric Emergency Care Applied Research Network) algorithm. This study was approved by the Ethics Committee of Sancaktepe Sehit Prof. Dr. Ilhan Varank Training and Research Hospital (Approval No: 08, Date: 11.01.2023). All procedures were conducted in accordance with the principles of the Declaration of Helsinki.

Variables and Outcome Measures

The primary outcome of this study was to assess the tendency of emergency physicians to order brain CT in pediatric patients presenting with head trauma, and to evaluate their level of knowledge and application of the PECARN algorithm.

The secondary outcome was to compare the baseline characteristics of physicians working in secondary and tertiary healthcare settings, their preference for using the PECARN rules, and their responses to the survey items.

The tertiary outcome was to determine the actual compliance rate with PECARN guidelines among physicians who reported routinely using this algorithm in clinical practice.

Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 29.0 (IBM Corp., Armonk, NY, USA). Categorical variables were presented as frequencies and percentages. Intergroup comparisons of categorical variables were performed using the Chi-square test, and Fisher's exact test was applied when appropriate. The Shapiro–Wilk test was used to assess the normality of distribution for continuous variables. Since all continuous variables were non-normally distributed, they were reported as medians and interquartile ranges (25th–75th percentiles), and comparisons were made using the Mann–Whitney U test. For comparisons involving more than two groups, post hoc analysis with Bonferroni correction was applied. A p-value of <0.05 was considered statistically significant.

Questionnaire Development

The questionnaire used in this study was specifically designed to evaluate physicians' approaches to pediatric head trauma and their compliance with the PECARN algorithm. The item pool was generated based on a review of existing literature and clinical decision rules for minor head trauma, such as PECARN, CATCH, and CHALICE. To ensure content validity, the draft questionnaire was reviewed by three senior emergency medicine specialists experienced in pediatric trauma care. Their feedback was incorporated to refine the clarity, relevance, and comprehensiveness of the items.

Following expert review, a pilot test was conducted with 10 emergency physicians to evaluate the clarity and applicability of the questionnaire in real-world clinical contexts. Based on the feedback received during this phase, minor linguistic and structural adjustments were made to improve understandability and consistency across items.

The final version of the questionnaire consisted of 18 Likert-scale items assessing CT imaging preferences in various pediatric trauma scenarios, and 4 items capturing participants' demographic and professional characteristics, including age, gender, years of experience, and current workplace setting **(Annex-2).**

Results

A total of 202 out of 450 emergency medicine specialists and emergency medicine residents working in the province of Istanbul participated in our survey study, which we conducted between February 5 and March 5. All of the volunteers who filled out the questionnaire form completed the form completely and none of the participants were excluded. A survey was sent to physicians working in Istanbul using the Google Survey app, and all physicians who filled out the form were included in the study. No selection was made.

The median age of the participants was 31 years (28-35), the median clinical experience was 6 years (3- 10) and 103 (51%) were female. 129 (63.9%) participants worked in the EDs of tertiary hospitals and 73 (36.1%) participants worked in the EDs of secondary hospitals. 138 (68.3%) participants stated that the decision to perform brain CT was based on physician's prediction and 64 (31.7%) participants stated that the decision was based on PECARN guidelines. The demographic data of the participants are summarized in **Table 1**.

Table 1: Demographic Data of Participants

Variable	*Median (25-75% quartiles) / n (%)*
▪ Age	31 (28–35)
▪ 2nd level hospital staff	33 (29- 39)
▪ 3rd level hospital staff	30 (27-34)
▪ Gender (female)	103 (51%)
▪ Clinical experience (years)	6 (3–10)
▪ The center where the participant works (TRH)	129 (63.9%)

TRH: Training and Research Hospital

The median age of the physicians working in the ED of a tertiary hospital was 30 (27- 34), while the median age of the physicians working in the ED of a secondary hospital was 33 (29- 39), and the difference was found to be statistically significant (p=0.001).

The participants were divided into two groups as physicians working in the ED of a tertiary care hospital and physicians working in the ED of a secondary care hospital according to the nature of the hospital they worked in.

The median clinical experience of physicians working in the ED of a tertiary hospital was calculated as 5 (3- 9) years, while the median clinical experience of physicians working in the ED of a secondary hospital was calculated as 8 (5- 14) years and the difference was statistically significant (p<0.001). We thought that the fact that tertiary care hospitals are also training hospitals was the reason for less clinical experience.

Table-2 shows the clinical experience of the participants.

34.9% of the physicians working in the ED of the tertiary care hospital and 26% of the physicians working in the ED of the secondary care hospital stated that they followed the PECARN rules on brain CT scanning and the difference was not statistically significant (p=0.194).

Table 2: Participants' Clinical Experience

	Median (25-75% quartiles)
▪ Clinical experience	6.5 (1-25)
▪ 2nd level hospital staff	8 (5-14)
▪ 3rd level hospital staff	5 (3-9)

When the responses of the physicians working in tertiary and secondary care EDs to the survey questions were compared, it was seen that the only question that showed a significant difference between the two groups in the omnibus test was 'I would have a CT scan if the patient has a headache that worsens after 2 hours of observation' (p=0.005). When post-hoc analysis was performed, it was seen that the difference was caused by those who answered "agree" and "disagree" to this question. 94.3% of the physicians working in the ED of a tertiary hospital and 81.3% of the physicians working in the ED of a secondary hospital agreed with this question and the difference was statistically significant (p=0.016, Bonferroni correction applied). There was no significant difference between physicians working in tertiary and secondary care EDs in the other questions.

When the extent to which physicians who stated that they preferred PECARN guidelines for brain CT ordering actually followed PECARN guidelines was analyzed, only 6.3% of the 64 physicians who stated that they ordered brain CT according to PECARN guidelines answered "agree" or "strongly agree" to the 10 questions measuring compliance with PECARN guidelines. Of the 138 physicians who followed their clinical prediction on brain CT ordering, 5.8% answered "agree" or "strongly agree" to the 10 questions measuring compliance with PECARN guidelines. There was no statistical difference between the rates of compliance with PECARN rules among physicians who said that they followed PECARN rules and those who said that they followed clinical prediction (p=0.562, Fisher Exact) **(Table-3).**

When the age and clinical experience of physicians who did and did not comply with PECARN rules according to the survey questions were analyzed, no significant difference was found between the two

groups in terms of age and clinical experience (p=0.086, p=0.247, respectively) **(Table-3).**

Table 3: Comparison of PECARN compliance rates between physicians who rely on clinical judgment and those who follow PECARN rules

	PECARN Compliance (+)	PECARN Compliance (–)	p-value
▪ Clinical judgment	8 (5.8%)	130 (94.2%)	0.562
▪ PECARN rules	4 (6.3%)	60 (93.8%)	—
▪ Age (years)	35 (29–40)	31 (28–35)	0.086
▪ Clinical experience (years)	4 (8–14)	6 (3–10)	0.247

Note: Data are presented as n (%) for categorical variables and median (interquartile range) for continuous variables.

When the results of the questionnaire were analyzed, one of the results that may draw attention even if it does not show a statistically significant difference is that 61.8% of physicians decided to perform CT regardless of the patient's clinic. In another question, we planned to examine the effect of fear of malpractice on the tendency of patients to undergo CT scan. 85.7% of the physicians who answered the question stated that it was a factor in their decisions.

Discussion

In our country, pediatric trauma constitutes a significant proportion of ED (ED) admissions, with head trauma being one of the most frequent injuries in childhood [10]. Diagnostic evaluation is often challenging due to communication difficulties and limited cooperation in pediatric patients. While cranial CT is frequently used, clinical decision rules such as PECARN, CATCH, and CHALICE have been developed to guide imaging [9]. However, most of these tools were created in high-income Western countries with lower ED visit volumes [11].

ED admissions in our country are considerably higher compared to Western settings [12]. Increased patient load and physician shortages contribute to heightened malpractice concerns, necessitating rapid and accurate care. Although scoring systems aim to standardize diagnosis and management, their practicality in overcrowded EDs—where time per patient is limited—is debatable. As a result, physicians may be more inclined to rely on rapid imaging rather than structured decision tools.

Upon evaluation of the study population, it was noted that the participants were relatively young. This may be attributed to the inclusion of physicians working in tertiary care centers, which primarily serve as training institutions for residency programs. The gender distribution among participants was found to be balanced. In contrast to a study conducted by Yılmaz et al., in 2021, which reported a predominance of male emergency physicians, our findings suggest a notable increase in the proportion of female physicians in emergency medicine [13]. Additionally, it was observed that the PECARN clinical decision rule—one of the key tools used in the evaluation and management of pediatric head trauma—was not commonly utilized. Instead, the majority of physicians relied on clinical judgment in their decision-making process.

In our study, we observed that the PECARN scoring system—one of the key tools in the diagnostic and follow-up processes for pediatric patients—was not frequently utilized by most physicians, who instead relied predominantly on their clinical judgment. In a study conducted by McGraw et al., [10], various clinical decision rules, including PECARN, were compared for their effectiveness in the management of minor head trauma. The authors concluded that the use of the PECARN algorithm was associated with a reduction in the number of cranial CT scans performed. Based on our findings, we believe that the limited use of structured decision-making tools such as PECARN among our physicians may contribute to an increased rate of potentially unnecessary CT imaging.

When analyzing our study results, we found that approximately 70% of participants selected "agree" or "strongly agree" in response to the need for cranial CT in the presence of altered mental status following trauma. This suggests that changes in mental status significantly influenced CT decision-making, regardless of whether a structured clinical decision rule was applied. In a systematic review conducted by Lumba et al., a correlation was identified between the severity of mental status impairment and the likelihood of detecting pathology on CT imaging [14]. Similarly, the PECARN criteria designate altered mental status as a clear indication for head CT in pediatric patients.

The importance of effective communication with family members in the management of pediatric patients is well recognized. Even during critical procedures such as resuscitation, the presence of family members—when cooperative—has been shown to provide psychological benefits. In a study by Dainty et al., the presence of family during resuscitation was associated with positive outcomes for family members, including emotional processing and acceptance [15].

In our survey, 61.8% of participants agreed or strongly agreed with the statement that brain CT be performed immediately upon family request, regardless of the patient's clinical status. Similarly, in response to a related question assessing whether family demands

influence the clinical decision to order CT, approximately 60% of respondents acknowledged that family preference played a role in their imaging decisions.

This influence of parental demands—despite not being part of validated clinical scoring systems—suggests a possible link to physicians' fear of malpractice or exposure to violence. According to the 2024 Activity Report of the Ministry of Health, approximately 50 workplace violence-related "white code" reports are filed daily in Turkey [16]. Furthermore, malpractice litigation in the country has shown a significant upward trend. Between 1990 and 2000, 653 malpractice-related expert opinions were requested from the Council of Forensic Medicine, whereas between 2012 and 2014, this number had risen to 1,320 for the First Specialization Board [17].

In our study, 85.1% of physicians agreed or strongly agreed that malpractice concerns and ED workload influenced their decision to order CT scans. These findings suggest that the rising frequency of malpractice claims may contribute to an increase in unnecessary imaging.

When participant demographics were examined, physicians working in secondary-level hospitals were generally older and more experienced than those in tertiary care centers. While it could be assumed that this would lead to variations in clinical decision-making, responses to most survey items were largely consistent across both groups.

Approximately 32% of participants reported adhering to the PECARN algorithm in their clinical practice. In comparison, a study conducted by Velasco et al., found that over 50% of physicians in four EDs in Spain reported compliance with PECARN guidelines, a notably higher rate than observed in our multicentre study [18]. Moreover, when the responses of participants who stated they followed PECARN were analyzed in detail, it was revealed that many of them did not actually adhere to the criteria in practice.

One of the limitations of our study is the lack of data regarding the professional status of participants—whether they were general practitioners, residents, or specialists—which was not included in the analysis. We believe that the inclusion of this information would have enabled valuable subgroup analyses and may have yielded more detailed insights.

Although the study was conducted in multiple centers, increasing the number of participating institutions could enhance the generalizability and precision of the findings. Lastly, while we observed a low level of adherence to the PECARN criteria, the underlying reasons for this noncompliance were not thoroughly investigated. We believe that further studies are warranted to explore the contributing factors in greater depth.

Conclusion

Our findings indicate that adherence to the PECARN decision rule in the evaluation of minor head trauma in pediatric patients is considerably low. To address this issue, we recommend the implementation of nationwide training programs and the development of standardized institutional protocols aimed at increasing algorithm compliance.
Factors contributing to noncompliance—particularly parental expectations, fear of malpractice, and the threat of violence—must be thoroughly evaluated and addressed in future educational and policy initiatives.

Author contribution statement

All authors (GA, SAİ, HAK, MFC İT) participated in the planning, writing, editing, and review of this manuscript.

Conflicts of interest

None Declared.

Ethical approval

This study was approved by the Ethics Committee of Sancaktepe Sehit Prof. Dr. Ilhan Varank Training and Research Hospital (Approval No: 08, Date: 11.01.2023).

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References

1. Çalik M, Ersoy AH, Ekin EE, Öztürk D, Güleç SG. Assessment of cost-effectiveness of computerized cranial tomography in children with mild head trauma. Diagnostics (Basel). 2022;12(11):2649. doi:10.3390/diagnostics12112649.
2. Homer CJ, Kleinman L. Technical report: minor head injury in children. Pediatrics. 1999;104(6):e78. doi:10.1542/peds.104.6.e78.
3. Pandor A, Goodacre S, Harnan S, et al. Diagnostic management strategies for adults and children with minor head injury: a systematic review and an economic evaluation. Health Technol Assess. 2011;15(27):1–202. doi:10.3310/hta15270.
4. Araki T, Yokota H, Morita A. Pediatric traumatic brain injury: characteristic features, diagnosis, and management. Neurol Med Chir (Tokyo). 2017;57(2):82–93. doi:10.2176/nmc.ra.2016-0191.
5. Miglioretti DL, Johnson E, Williams A, et al. The use of computed tomography in pediatrics and the associated radiation exposure and estimated cancer risk. JAMA Pediatr. 2013;167(8):700–7. doi:10.1001/jamapediatrics.2013.311.
6. Brenner DJ, Hall EJ. Computed tomography—an increasing source of radiation exposure. N Engl J Med. 2007;357(22):2277–84. doi:10.1056/NEJMra072149.
7. Brenner DJ. Estimating cancer risks from pediatric CT: going from the qualitative to the quantitative. Pediatr Radiol. 2002;32(4):228–44. doi:10.1007/s00247-002-0671-1.
8. Pearce MS, Salotti JA, Little MP, et al. Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: a retrospective cohort study. Lancet. 2012;380(9840):499–505. doi:10.1016/S0140-6736(12)60815-0.
9. McGraw M, Way T. Comparison of PECARN, CATCH, and CHALICE clinical decision rules for pediatric head injury in the ED. CJEM. 2019;21(1):120–4. doi:10.1017/cem.2018.444.
10. Boğan M, Altınsoy HB, Oktay M. Acil serviste tespit edilen çocukluk çağı kafa tası kırıklarının mortalite ve morbiditesinin incelenmesi. Van Sağlık Bilimleri Dergisi. 2018;14(2):137–43.
11. Dalziel K, Cheek JA, Fanning L, et al. A cost-effectiveness analysis comparing clinical decision rules PECARN, CATCH, and CHALICE with usual care for the management of pediatric head injury. Ann Emerg Med. 2019;73(5):429–39. doi:10.1016/j.annemergmed.2018.09.030.
12. Ataman MG, Sariyer G, Saglam C, Karagoz A, Unluer EE. Factors relating to decision delay in the ED: effects of diagnostic tests and consultations. Open Access Emerg Med. 2023;15:119–31. doi:10.2147/OAEM.S384774.
13. Yılmaz N, Alkan A, Ertümer AG, Kuh Z. Evaluation of medical specialties in terms of gender. Cukurova Med J. 2021;46(3):1257–66. doi:10.17826/cumj.906459
14. Lumba-Brown A, Yeates KO, Sarmiento K, et al. Diagnosis and management of mild traumatic brain injury in children: a systematic review. JAMA Pediatr. 2018;172(11):e182847. doi:10.1001/jamapediatrics.2018.2847.
15. Dainty KN, Atkins DL, Breckwoldt J, Maconochie I, Schexnayder SM, Skrifvars MB, et al. Family presence during resuscitation in paediatric and neonatal cardiac arrest: a systematic review. Resuscitation. 2021;159:150–64. doi:10.1016/j.resuscitation.2021.01.017.
16. T.C. Sağlık Bakanlığı. T.C. Sağlık Bakanlığı 2024 Yılı Faaliyet Raporu [Internet]. Ankara: Strateji Geliştirme Başkanlığı; 2025 Feb 28 [cited 2025 Jul 19]. Available from: https://dosyamerkez.saglik.gov.tr/Eklenti/50450/0/tc-saglik-bakanligi-2024-yili-faaliyet-raporupdf.pdf
17. Kılan S. Hizmet kusurundan kaynaklanan hatalı tıbbi uygulama davalarının Danıştay kararları ışığında analizi [master's thesis]. İzmir: İzmir Bakırçay Üniversitesi, Lisansüstü Eğitim Enstitüsü; 2022. Turkish. Available from: https://acikerisim.bakircay.edu.tr/bitstreams/498840ba-6d9a-4cdf-8a45-9b16358d8798/content
18. Velasco R, Arribas M, Valencia C, Zamora N, Fernández SM, Lobeiras A, et al. Adecuación del manejo diagnóstico del traumatismo craneoencefálico leve en menores de 24 meses a las guías de práctica clínica de PECARN y AEP [Compliance with the PECARN and AEP guidelines in diagnostic approach of mild head trauma in patients younger than 24 months old]. An Pediatr (Barc). 2015;83(3):166–72.

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Evaluation Of Stress Hyperglycemia on the Admission and Follow-Up of Patients Admitted to The Pediatric Emergency Department

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Abstract

Background: This study aims to examine the demographic and clinical characteristics of patients with stress hyperglycemia (SH) at admission to the pediatric emergency department and investigate whether diabetes develops in the follow-up of patients with SH.

Methods: Data were collected retrospectively from the medical records of all children aged 1 month –18 years who visited the Pediatric Emergency Department during the years 2017–2022 and had a glucose level of >200 mg/dl. Patients with a final diagnosis or history of diabetes mellitus were excluded from the study. Data collected included age, gender, blood glucose level, treatment with medications affecting blood glucose levels, white blood cells (WBC), C-reactive protein (CRP), pH, lactate levels, hospitalization, and diagnosis in the Pediatric Emergency Department. The development of diabetes in the follow-up was determined by insulin, C-peptide, and HbA1c levels. A p-value below 0.05 was considered significant in all analyses.

Results: SH was observed in 818 patients who applied to the emergency department in the last five years. The median age of patients was 22 months (1-214 months). Age of 51.2% of the patients was between 1-23 months.57.2% of the patients were male, and 42.9% were female. The male/female ratio in the study was 1.3/1. The most common diagnoses of patients with SH in the emergency department were lower respiratory tract infection (59.5%), tonsillitis (11.1%), and acute gastroenteritis (10.5%), respectively. The median blood glucose level of the patients was 232 mg/dl (201-438 mg/dl). The blood glucose level of 9.3% of the patients was above 300 mg/dl. 15.7% of patients with SH were hospitalized. HbA1c level was lower than 5.5% in all patients who had an HbA1c test during their follow-up (n=45). Patients who received salbutamol (p=0.013) or corticosteroids (p=0.004) had higher blood glucose levels, and those who received fluid therapy (p=0.001) had lower blood glucose levels in the emergency department. Blood glucose levels were similar in hospitalized and non-hospitalized patients (233 mg/dl vs 227 mg/dl, p=0.536).

Conclusions: SH is a common finding among children evaluated in the Pediatric Emergency Department. Our findings regarding children with SH do not indicate an increased risk of diabetes.

Keywords
Children, Diabetes, Stress Hyperglycemia

Introduction

Stress hyperglycemia (SH), characterized by increased glycogenolysis and gluconeogenesis with insulin resistance, is a normal homeostatic response to acute stress. SH is frequently seen in children because of febrile convulsions, respiratory tract infections, and some commonly used medical treatments [1]. SH is not an underlying disease; it is defined as the plasma glucose level rising above 150 mg/dl due to an acute or critical illness and returning to normal when the underlying stress is eliminated [2, 3].

The frequency of SH in children is not known precisely. It has been reported that 3.8-5% of the children without diabetes who applied to the emergency department had a plasma glucose level above 150 mg/dL, and 20-35% of the children with critical illness or followed in the intensive care unit had a plasma glucose level above 200 mg/dl [4]. Evidence-based guidelines have been created using extensive data on Type 1 Diabetes Mellitus (DM) and its treatment in children. However, data on the pathogenesis of SH in children are limited and are often derived from adult studies. In addition, it is not precisely known when to treat SH, when to start the

treatment, and which agents to use. Moreover, SH is associated with poor prognostic outcomes such as prolonged hospital stay and increased mortality, especially in critically ill patients, indicating that SH encountered in the intensive care setting should be treated [5].

It was aimed to define the demographic and clinical characteristics of children who applied to the emergency department with a blood glucose level over 200 mg/dl and to determine whether they would develop diabetes in the future regarding their laboratory values at admission and HbA1c, insulin, and C-peptide levels in the controls. This study also aimed to determine SH patients' hospitalization rates and examine the differences between hospitalized patients and those who were not.

Materials and Methods

Study design and participants

This study was planned as a single center and retrospective study at Health Sciences University Ankara Atatürk Sanatorium Training and Research Hospital. Between January 1, 2017, and January 1, 2022, it was planned to retrospectively include patients who presented to the Pediatric Emergency Clinic of SBU Ankara Atatürk Sanatoryum Education and Research Hospital, who did not have a known diagnosis of diabetes or hypoglycemia, and whose blood sugar level was measured above 200 mg/dL.

During the study period, patients who presented to the emergency department for any reason and had no history or diagnosis of diabetes were screened from the hospital's digital archives. Data extracted from patient records included age, gender at presentation, presenting symptoms, diagnoses made in the emergency department, and treatments recommended at the time. While reviewing blood tests, results such as white blood cell (WBC) count, C-reactive protein (CRP), venous blood pH, lactate levels, as well as the presence of glucose and ketones in the urine, were recorded from the files. Additionally, the patients' current status in the emergency department, whether they were transferred to other centers, and whether they were admitted to inpatient wards were documented.

To assess whether these patients developed diabetes during subsequent visits, insulin, C-peptide, and HbA1c tests were evaluated. Insulin was requested in 50 patients, while C-peptide and HbA1c tests were requested in 45 patients. Normal insulin levels before puberty were considered up to 5-10 µU/L; after puberty normal levels were accepted as up to 10-17 µU/L in girls and 13-20 µU/L in boys. The normal reference range for C-peptide was 1.1–3.2 ng/mL, and for HbA1c, it was between 4% and 5.6%.

Patients' age, gender, symptoms in the admission to the emergency department, diagnosis in the emergency department, and recommended treatments were taken from the files. Laboratory values (HbA1c, insulin, and C-peptide) of the patients included in the study were taken from hospital records. HbA1C values were determined using the blood tubes anticoagulated with potassium-ethylenediamine tetra acetic acid (K3EDTA) in the Adams HA-8180V fully automatic HbA1c device in the Biochemistry Laboratory of the Ministry of Health Ankara Atatürk Sanatorium Training and Research Hospital. Insulin and C-peptide levels were determined in dry gel tubes and Abbott Architect I2000 branded device.

SH is defined by the "American Diabetes Association" as a fasting plasma glucose level above 126 mg/dl or a random glucose level above 200 mg/dl in patients who did not have diabetes before. As the study's design was retrospective and blood samples were taken in an emergency setting, values above 200 mg/dl were used to diagnose SH to exclude fasting and postprandial effects, in line with the "American Diabetes Association" recommendations.

Patients with blood glucose levels above 200 mg/dL were included in the study, and based on their blood glucose measurements, the patients were divided into two groups:

- Group 1: Blood glucose 200–299 mg/dL
- Group 2: Blood glucose exceeding 300 mg/dL

Statistical Analysis

Statistical analyses were performed using SPSS version 22.0 (Chicago, USA). The conformity of the variables to the normal distribution was checked using visual (histogram and probability graphs) and analytical methods (Kolmogorov Smirnov, Shapiro-Wilk test). Descriptive statistics were expressed as the mean and standard deviation in normally distributed data, median and minimum maximum in non-normally distributed data, and numbers and percentages in nominal data. "Independent groups t-test" was used to test the differences between two groups for normally distributed numerical variables, "Mann-Whitney U test" for non-normally distributed numerical variables, and "Chi-square analysis" and "Fisher Exact test" were used to compare nominal data. In all analyses, values below $p<0.05$ were considered statistically significant.

Ethics committee approval

The necessary permission was obtained from Ankara Atatürk Sanatorium Training and Research Hospital Clinical Research Ethics Committee with the decision numbered 2012-KAEK-15/2524 on 24.05.2022.

Results

A total of 547,638 patients were evaluated. Blood glucose levels were requested for 125,317 of these patients. Among them, 1,370 patients had blood glucose levels exceeding 200 mg/dL.

Of these 1,370 patients, 552 were excluded from the study and a total of 818 patients were included in the final analysis **(Figure-1).** The median age of 818 patients included in the study was 22 months (1-214 months). 51.2% of them were 1–23-month-old, 20% 24–47-month-old, 11.2% 48–71-month-old, and 17.5% 72-month-old and above. 57.2% of the patients were male, and 42.8% were female. The male/female ratio in the study was 1.3/1. The most common symptoms of patients who applied to the emergency department were cough (67.1%), throat ache (66.3%), and fever (65.2%). Regarding the diagnoses of the patients, 487 patients (59.5%) were diagnosed with lower respiratory tract infection (LRTI), 91 patients (11.1%) with tonsillitis, and 86 patients (10.5%) with acute gastroenteritis **(Table-1)**.

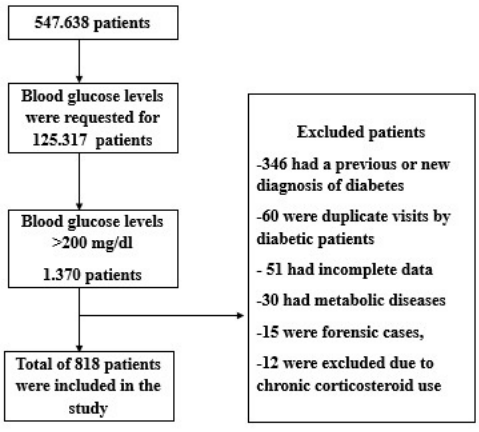

Figure 1: Flowchart showing number of patients of the study

The treatments applied to patients with SH in the emergency department were salbutamol (24.1%), salbutamol+ corticosteroid (CORT) + paracetamol (PCT) + (non-steroidal anti-inflammatory) NSAID (22.9%), PCT+NSAID (19.6%), and fluid (18.6%). The median blood glucose level of the patients was 232 mg/dl (201-438 mg/dl). The blood glucose level of 9.3% of the patients was above 300 mg/dl **(Figure 2).**

Table 1: Demographic Data of Patients (n=154)

Symptoms	**n**	**%**
Cough	549	67.1
Throat ache	542	66.3
Fewer	533	65.2
Malaise	399	48.8
Shortness of breath	205	25.1
Neck pain	125	15.3
Stomach ache	111	13.6
Diarrhea	101	12.3
Vomiting	89	10.9
Constipation	23	2.8
Dermatological complaints	19	2.3
Urinary burning	11	1.3
Patient's diagnosis	**n**	**%**
LRTI	487	59.5
Tonsillitis	91	11.1
Acute gastroenteritis	86	10.5
URTI	66	8.1
Convulsion	33	4.0
Sinusitis	17	2.1
Stomach ache	14	1.7
Urticaria	13	1.6
UTI	11	1.3
Other	35	4.2
Treatments	**n**	**%**
Salbutamol	197	24.1
Salbutamol+ CORT+PCT+ NSAID	187	22.9
PCT+ NSAID	160	19.6
Fluid	147	18
Salbutamol+ CORT	112	13.7
CORT	14	1.7
In admission to the ED	**n**	**Mean (Min-Max)**
Glucose (mg/dl)	818	232 (201-438)
WBC (10^3/µL)	818	10.5 (1.7-30.7)
CRP (mg/dL)	818	5.6 (0-120)
pH	586	7.37 (7.25-7.54)
Lactate (mmol/L)	585	3.1 (0.5-7.6)
In the control	**n**	**Mean (Min-Max)**
Insulin (µU/L)	50	10.7 (2.2-67.1)
C-peptide (ng/mL)	45	5.2 (0.6-21.1)
HbA1c (%)	45	5.3 (4.0-5.5)

LRTI: *Lower respiratory tract infection*, **URTI**: *Upper respiratory tract infection*, **UTI**: *Urinary tract infection*, **CORT**: *Corticosteroid*, **PCT**: *Paracetamol*, **NSAID**: *Non-steroid anti-inflammatory drug*, **ED**: *Emergency department*, **WBC**: *White blood cell*, **CRP**: *C reactive protein*, **HbA1c**: *Hemoglobin A1C*

Insulin levels ranged from 2.2 µU/L to 67.1 µU/L. The normal insulin level before puberty is 10 µU/L; after puberty, up to 17 µU/L is considered normal in girls and 13 µU/L in boys. C-peptide values of the patients ranged from 0.6 ng/mL to 21.1 ng/mL. C-peptide normal value range is 1.1-3.2 ng/ml. HbA1c level was lower than 5.5% in all patients whose HbA1c was tested. The mean HbA1c level was 5.3%. The normal range for HbA1c is between 4.0% and 5.6% **(Table 1).**

When the patients were compared according to their blood sugar levels, the most common symptom was

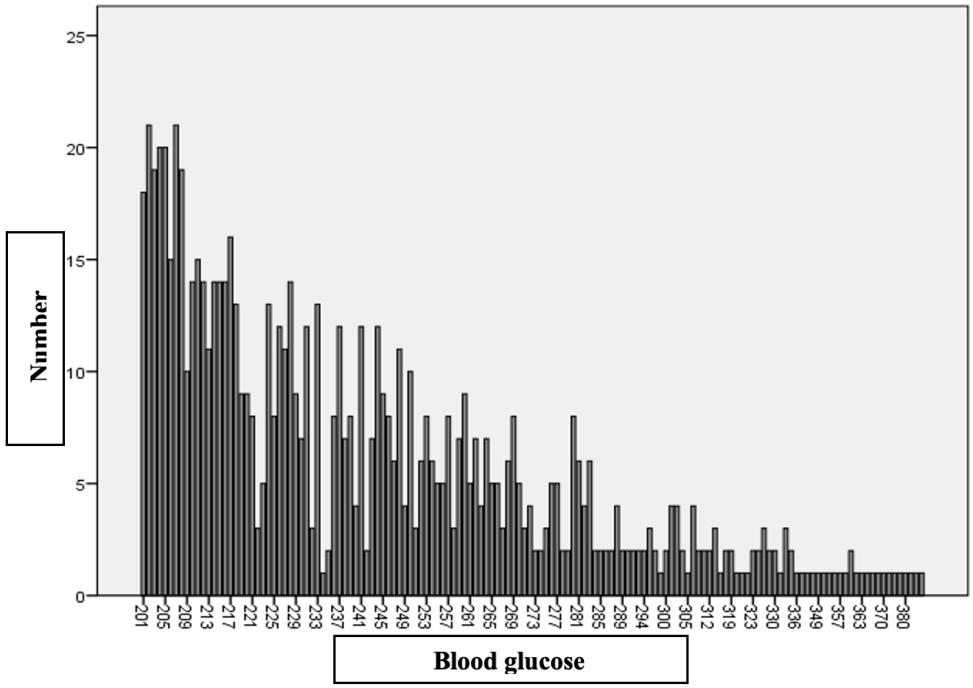

Figure 2: Blood glucose levels of patients in the emergency department

cough, and the most common diagnosis was LRTI, and there was no significant difference between the two groups (p>0.05). The use of CORT as treatment was found to be significantly higher in patients with blood glucose ≥300 mg/dl (p=0.028).

The mean insulin value was 9.6 in the group whose blood glucose level was between 200-299 and 21.7 in the group whose blood glucose level was above 300. However, this difference was not statistically significant (p=0.081). No significant difference was observed in HbA1c and other laboratory data **(Table 2).**

Table 2: Comparison of Laboratory Data of Patients According to Blood Glucose Levels

Mean, (Min-Max)	BGL 200-299 mg/dl (n=742)	BGL≥300 mg/dl (n=76)	p-value
WBC	10.6 (2.6-30.7)	10.1 (1.7-29.2)	0.14
CRP (mg/dL)	5.5 (0-120)	5.9 (0-92)	0.56
pH	7.37 (7.25-7.49)	7.37 (7.30-7.54)	0.81
Lactate (mmol/L)	3.1 (0.5-7.6)	3.0 (1.2-6.8)	0.99
Insulin (µU/L)	9.6 (2.2-67.1)	21.7 (4.4-61.1)	*0.08*
C-peptide(ng/mL)	4.9 (0.6-21.1)	6.1 (3.1-20.4)	0.15
HbA1c (%)	5.2(4.0-5.5)	5.3 (4.3-5.4)	0.91

BGL: *Blood Glucose Level*, **WBC**: *White blood cell*, **CRP**: *C reactive protein*, **HbA1c**: *Hemoglobin A1C*

The patients who received salbutamol during the treatment had higher blood glucose levels (p=0.013). The blood glucose levels of patients who used corticosteroids (CORT) in the emergency department were also higher (p=0.004).

Discussion

Hyperglycemia frequently occurs during a severe disease [6]. In hyperglycemia, glycogenolysis and gluconeogenesis are stimulated by the effects of cortisol, catecholamine, glucagon, and proinflammatory cytokines. This stimulus causes the emergence of peripheral insulin resistance. Although SH was thought to be a normal metabolic response to acute stress, it was reported to cause adverse clinical outcomes in pediatric and adult studies, including prolonged hospitalization, unnecessary drug use, and increased costs due to further tests [3]. It is especially wondered whether diabetes develops in the later stages in children with SH [7].

This study's plasma glucose threshold was set as 200 mg/dl while defining SH. However, in most studies, SH was defined as a plasma glucose level over 150 mg/dl in patients without known diabetes [3,5,8]. Some studies even accepted 126 mg/dl as the threshold [2]. On the other hand, the "American Diabetes Association" defined SH as a fasting plasma glucose level above 126 mg/dl in patients without diabetes mellitus, 140 mg/dl in hospitalized patients, and a random plasma glucose level above 200 mg/dl [9]. Since it was aimed to examine the SH frequency in patients admitted to the pediatric emergency department, those with a glucose level above 200 mg/dl were included in this study to eliminate the uncertainty about the fasting and postprandial status.

It is known that glucose levels rise temporarily during acute diseases. However, it is also suggested that SH may be the first sign of pancreatic beta cell damage and predisposes to the development of diabetes [10,11]. Saz et al. reported in their study conducted in Turkey that glucose metabolism disorder was not observed in the SH follow-ups of patients admitted to the emergency department with febrile disease [12]. Shehadeh et al. examined 36 patients with hyperglycemia after acute illness; the first phase of insulin response was low in 8 patients, and insulin autoantibodies were positive in 3 patients. However, they reported that none of the patients developed diabetes in their follow-ups 12-16 months later [13]. Therefore, it was thought that hyperglycemia developed during severe acute illness did not significantly affect the development of diabetes alone.

In this study, the HbA1c level of 818 patients diagnosed with SH at admission to the emergency department was below 5.5% in their subsequent controls. These patients' plasma glucose levels returned to normal in the follow-up and controls. It was observed that none of the patients diagnosed with SH in the emergency department developed diabetes in their controls. 9.3% of the patients had blood glucose levels above 300 mg/dl, but none developed diabetes in their follow-up, which is consistent with the literature.

Contrary to studies reporting that SH is a normal physiological response, there are also studies suggesting that SH facilitates the development of diabetes. The study of Oron et al. focused on the diagnosis of febrile infection in two patients who applied to the emergency department with a blood glucose level above 150 mg/dl. Patients' examination revealed that one patient's mother had gestational DM, the other patient had a family history of MODY, and heterozygous mutations in the glucokinase gene were observed in their genetic analysis. The study has suggested that SH with a family history may be associated with monogenic diabetes. However, only two cases were included in the study, which is a significant limitation [14].

Bae et al. reported that the frequency of 1-3-year-old patients was high in the SH population [14]. It has been attributed to the frequent monitoring of febrile diseases, which are an important cause of SH in this age group. On the other hand, regardless of SH, nearly half of the emergency department admissions were patients aged 5 years and younger [15]. In addition, the average age of patients with SH may vary depending on the characteristics of the emergency services. The average age of SH can be higher in pediatric emergency departments accepting trauma because traumas are mainly observed at the age of 5 and above. In our study, patients who underwent trauma and CPR were excluded, and the median age was 22 months; similar to the literature, approximately half of the patients were 1-24-month-old.

Valerio et al. Reported that the frequency of SH in children with febrile convulsions was higher than in children with only febrile disease [16]. In cases of hypoxic and ischemic damage such as febrile convulsions, hyperglycemia may not be harmful; on the contrary, it may be protective and increase cellular resistance against ischemia. SH between 140-220 mg/dl will keep cellular glucose uptake at the highest level without causing hyperosmolarity. In the current study, most of the patients with SH were patients diagnosed with LRTI; however, convulsions were observed in 4% of the patients. Many studies have reported that especially febrile convulsions are associated with SH. Unlike these findings, in the current study, the glucose level of patients diagnosed with convulsions was lower than those without a convulsion diagnosis. However, only patients with SH were included in the current study. This study's lower blood glucose level among febrile convulsion patients may be due to the immediate initiation of fluid treatment and making blood tests after the emergency intervention. Therefore, blood glucose levels may be lower.

Various pharmacological agents cause SH. Among them, the effect of corticosteroids on glucose metabolism is well known. Corticosteroids are preferred in many cases, such as asthma, rheumatological diseases, hematological diseases, and malignancies in pediatric patients. Corticosteroids cause hyperglycemia with insulin resistance, gluconeogenesis, and decreased insulin production [17,18]. In the study conducted by Donihi et al. in 2006, hyperglycemia was observed in a 1-month follow-up of 32 (64%) of 50 patients who took high-dose corticosteroids (over 40mg/day) for at least 2 days [19]. Although hyperglycemia is observed in all administration routes of corticosteroids (oral, intravenous, etc.), intravenous and high-dose administrations cause faster SH development [17]. In the current study, the blood glucose levels of patients treated with corticosteroids were higher, which supported this result. For the current study, it can be said that corticosteroids were frequently administered intravenously or orally to patients in the emergency department. Therefore, the blood glucose levels of the patients who took corticosteroid therapy in the emergency department may be higher.

Similar to corticosteroids, salbutamol is also known to be associated with hyperglycemia. β-2 agonists,

β-2 agonists, including salbutamol, are often preferred in asthma, cystic fibrosis, and chronic lung diseases. Activating β-2 receptors results in hyperglycemia with increased glycogenolysis and gluconeogenesis in the liver and muscles [20]. In the current study, patients most frequently received salbutamol treatment, and blood glucose levels were observed to be higher in these patients.

In the current study, insulin levels of 45 SH patients were measured in the controls. The median insulin level of these 45 patients was 10.7 μU/L. Since the patients in our study consisted of both pre-pubertal and pubertal children, it can be said that the median insulin level of 10.7 μU/L observed in this study is within the normal range.

It is known that disease severity affects admission to inpatient services [21]. In this study, the age of the patients admitted to the service was higher than non-hospitalized ones. However, approximately 42% of the patients admitted to the service were 1-23-month-old. In the current study, the diagnosis of LRTI was lower in patients admitted to the service than in non-admitted ones. The probable cause of this situation may be related to the comprehensive treatment of LRTI patients in the emergency department, or the severity of the disease is not high enough to require admission to the service. Similarly, the lower frequency of salbutamol treatment in patients admitted to the service supported that LRTI patients were primarily treated in emergency services.

Regarding the limitations of our study, the failure to obtain detailed anamnesis from the patients treated in the emergency department due to the lack of time caused us to be unable to conduct a more detailed analysis. Although 818 patients were included in the current study, only 45 patients had HbA1c levels in the controls, which masked the effect of SH on the development of diabetes. The limitations of our study are the retrospective design, the short follow-up periods of the patients, and not requesting HbA1c from every patient. Finally, more comprehensive data on SH could be obtained by comparing patients who applied to the emergency department but did not have SH with those diagnosed with SH.

Conclusion

As a result, it was thought that the impact of acute stress-induced SH in the development of diabetes in the future is low. We can help reduce families' anxiety levels by explaining to patients diagnosed with SH and their parents that this is likely to be a temporary condition associated with acute illness.

Author contribution statement

All authors (AAK, YY, ADB, UUI) participated in the planning, writing, editing, and review of this manuscript.

Conflicts of interest

None Declared.

Ethical approval

The necessary permission was obtained from Ankara Atatürk Sanatorium Training and Research Hospital Clinical Research Ethics Committee with the decision numbered 2012-KAEK-15/2524 on 24.05.2022.

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References

1. Argyropoulos T, Korakas E, Gikas A, et al. Stress Hyperglycemia in Children and Adolescents as a Prognostic Indicator for the Development of Type 1 Diabetes Mellitus. Front Pediatr. 2021;9:670976.
2. Srinivasan V, Spinella PC, Drott HR, et al. Association of timing, duration, and intensity of hyperglycemia with intensive care unit mortality in critically ill children. Pediatr Crit Care Med. 2004;5(4): 329–36.
3. Dungan KM, Braithwaite SS, Preiser JC. Stress hyperglycaemia. Lancet. 2009; 373:1798–807.
4. Srinivasan V. Stress hyperglycemia in pediatric critical illness: the intensive care unit adds to the stress! J Diabetes Sci Technol. 2012;6:37–47.
5. Fattorusso V, Nugnes R, Casertano A, Valerio G, Mozzillo E, Franzese A. Non-Diabetic Hyperglycemia in the Pediatric Age: Why, How, and When to Treat? Curr Diab Rep. 2018;18(12):140.
6. Marik PE, Bellomo R. Stress hyperglycemia: an essential survival response! Crit Care. 2013;17:305.
7. Ziegler AG, Nepom GT. Prediction and pathogenesis in type 1 diabetes. Immunity. 2010; 32:468–78.
8. Bordbar MR, Taj-Aldini R, Karamizadeh Z, Haghpanah S, Karimi M, Omrani GH. Thyroid function and stress hormones in children with stress hyperglycemia. Endocrine. 2012; 42:653–7.
9. Moghissi ES, Korytkowski MT, DiNardo M, Einhorn D, Hellman R, Hirsch B, et al. American Association of Clinical Endocrinologists and American Diabetes Association consensus statement on inpatient glycemic control. Diabetes Care. 2009; 32:1119–31.
10. Vardi P, Shehade N, Etzioni A, Herskovits T, Soloveizik L, Shmuel, et al.. Stress hyperglycemia in childhood: a very high risk group for the development of type I diabetes. J Pediatr. 1990; 117:75–7.
11. Herskowitz-Dumont R, Wolfsdorf JI, Ricker AT, et al. Transient hyperglycemia in childhood: identification of a subgroup with imminent diabetes mellitus. Diabetes Res. 1988;9:161–167.

12. Saz EU, Ozen S, Simsek Goksen D, Darcan S. Stress hyperglycemia in febrile children: relationship to prediabetes. Minerva Endocrinol. 2011;36(2):99-105.
13. Shehadeh N, On A, Kessel I, Perlman R, Even L, Naveh T, et al.. Stress hyperglycemia and the risk for the development of type 1 diabetes. J Pediatr Endocrinol Metab. 1997; 10:283-6.
14. Bae W, Ahn MB. Association between Stress Hyperglycemia and Adverse Outcomes in Children Visiting the Pediatric Emergency Department. Children (Basel). 2022;9(4):505.
15. Rasooly IR, Mullins PM, Alpern ER, Pines JM. US emergency department use by children, 2001-2010. Pediatr Emerg Care. 2014;30(9):602-7.
16. Valerio G, Franzese A, Carlin E, Pecile P, Perini R, Tenore A. High prevalence of stress hyperglycaemia in children with febrile seizures and traumatic injuries. Acta Paediatr. 2001; 90:618–22.
17. Tosur M, Viau-Colindres J, Astudillo M, Redondo MJ, Lyons SK. Medication-induced hyperglycemia: pediatric perspective. BMJ Open Diabetes Res Care. 2020;8(1):e000801.
18. Perez A, Jansen-Chaparro S, Saigi I, et al. Glucocorticoid-Induced hyperglycemia. J Diabetes. 2014;6:9–20.
19. Donihi AC, Raval D, Saul M, et al. Prevalence and predictors of corticosteroid-related hyperglycemia in hospitalized patients. Endocr Pract. 2006;12(4):358–62.
20. Dawson KP, Penna AC, Manglick P. Acute asthma, salbutamol and hyperglycaemia. Acta Paediatr. 1995; 84:305–7.
21. Yusuf S, Caviness AC, Adekunle-Ojo AO. Risk factors for admission in children with bronchiolitis from pediatric emergency department observation unit. Pediatr Emerg Care. 2012;28(11):1132-5.

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Original Article

Mesenteric Panniculitis and Systemic Inflammation: A Retrospective Analysis of Inflammatory Indices - a Retrospective Cross-sectional Study

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Abstract

Background: Mesenteric panniculitis (MP) is a nonspecific inflammatory pathological condition affecting the mesenteric adipose tissue. Data regarding systemic inflammatory markers in patients with MP are limited. We aimed that systemic inflammatory blood parameters, including those derived from complete blood count (CBC), would show a significant correlation with computed tomography (CT)-based severity scores in patients with MP.

Methods: This was a retrospective cross-sectional study. Patients aged 18 years and older who underwent abdominal CT scans for any reason and had concurrent comprehensive laboratory tests between January 1, 2015, and January 1, 2020, were included. Demographic data and laboratory findings were reviewed. White blood cell count, hemoglobin, neutrophil count, lymphocyte count, platelet count, platelet-to-lymphocyte ratio (PLR), neutrophil-to-lymphocyte ratio (NLR), systemic inflammatory response index (SIRI), systemic immune-inflammation index (SII), and aggregate index of systemic inflammation (AISI) were evaluated. MP severity was scored between a minimum of 3 and a maximum of 15 points and classified as mild (score 3–5), moderate (score 5–9), and severe (score 10–15).

Results: A total of 80 patients were included in the study. The median total MP score was found to be 6. Among the patients, 36.2% were classified as mild, and 63.8% as moderate-to-severe. When the patients were evaluated based on the severity of MP, there were no statistically significant differences in comorbidities or systemic inflammatory parameters (NLR, PLR, SII, SIRI and AISI) (all values $p>0.05$). Although the density of mesenteric fat was higher compared to visceral adipose tissue, this difference was not statistically significant in relation to systemic inflammatory parameters ($p>0.05$).

Conclusions: In patients with mesenteric panniculitis (MP), in the absence of accompanying acute or chronic infectious or inflammatory pathologies, it does not appear to affect the systemic inflammatory response.

Keywords
Mesenteric panniculitis, Computed tomography, NLR, PLR, SII, AISI, systemic inflammatory response

Introduction

Mesenteric panniculitis (MP) is a chronic inflammatory disorder affecting the mesenteric adipose tissue, diagnosed based on the observation of mesenteric fat congestion and haziness on abdominal computed tomography (CT). Although the exact etiology remains unclear, it has been associated with prior trauma, concurrent abdominal infections, infestations, and malignancies such as lymphoma and colon carcinoma [1]. MP is a rare condition, with a prevalence ranging from 0.16% to 3.3% [2]. It is more common in men, with a male-to-female ratio of approximately 2:3 [3]. The disease typically occurs in Caucasians and is most diagnosed in individuals aged between 60 and 70 years [4], although rare cases have been reported in children [5].

While some cases are asymptomatic, approximately 50% of patients present to emergency departments with nonspecific symptoms such as abdominal discomfort (78%), pain, constipation, and diarrhea. Occasionally, it may present as an abdominal mass, leading to bowel obstruction or ischemia, which may require urgent surgery [5]. Diagnosis is achieved by excluding other differential diagnoses such as acute cholecystitis and appendicitis. CT imaging and routine blood tests are typically used in the diagnostic process [6, 7]. MP is primarily

diagnosed through radiological evaluation, with CT and magnetic resonance imaging (MRI) being the most reliable methods for detection.

There are two main forms of MP: the classic form characterized by inflammation, necrosis, and fat degeneration, and the retractile form, where retraction of surrounding structures is observed [1]. The disease generally follows a benign course, and in the absence of other abdominal pathology, treatment is symptomatically managed with medical therapy.

Previous studies have suggested that blood tests in MP patients are generally within normal limits. However, erythrocyte sedimentation rate and C-reactive protein levels may be elevated as a response to the inflammatory process [8-10]. There is limited data regarding other systemic inflammatory markers. We aimed that systemic inflammatory blood parameters, including those derived from complete blood count (CBC), would show a significant correlation with CT-based severity scores in patients with MP.

Materials and Methods

Study design

This retrospective cross-sectional study was conducted at Ankara Atatürk Sanatorium Training and Research Hospital. This 780-bed tertiary care facility is located in a bustling provincial center. Approval for the study was obtained from the local ethics committee with protocol number 2023-KAEK/15-2696. This study was prepared and reported in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines.

Study population

Patients aged 18 years and older who underwent abdominal CT for any reason and had simultaneous laboratory tests between January 1, 2015, and January 1, 2020, were included. These patients had presented to the general surgery, emergency medicine, internal medicine, urology, or gastroenterology departments with complaints of abdominal pain or flank pain. Patients with no MP findings on CT scans, patients under 18 years of age, patients with artefacts preventing CT evaluation, patients with chronic inflammatory diseases, pregnant women, and those with missing data were excluded from the study. Patients with chronic inflammatory diseases were excluded to avoid potential confounding effects on systemic inflammatory markers, as these conditions could independently elevate inflammatory indices. Pregnant women were excluded due to physiological hematological changes during pregnancy, which could alter systemic inflammatory parameters and affect the study outcomes. Only patients in whom laboratory blood tests were performed within three days of CT imaging were included in the study, in order to minimize potential variability in systemic inflammatory markers over time.

Data Collection

Demographic data (age, gender, etc.), comorbidities, history of prior surgeries, and laboratory findings were obtained through retrospective review of patient records. Laboratory parameters evaluated included white blood cell count, hemoglobin, neutrophils, lymphocytes, platelets, platelet-to-lymphocyte ratio (PLR), neutrophil-to-lymphocyte ratio (NLR), systemic inflammatory response index (SIRI), systemic immune-inflammation index (SII), and aggregate index of systemic inflammation (AISI). The inflammatory indices were calculated using the following formulas:
PLR = Platelet / Lymphocyte
NLR = Neutrophil / Lymphocyte
SII = (Platelet × Neutrophil) / Lymphocyte
SIRI = (Neutrophil × Monocyte) / Lymphocyte
AISI = (Neutrophil × Platelet × Monocyte) / Lymphocyte

Imaging

CT reports containing the terms “mesenteric panniculitis” and “mesenteric lymph node” were reviewed **(Figure-1).** The presence of MP (such as lymph nodes, fat stranding, etc.) and other abdominal pathologies (e.g., malignancies, acute pancreatitis, acute appendicitis) were assessed by a radiologist blinded to the study outcomes.
CT findings were categorized as:
“Mass effect” (compression of adjacent intestines),
“Increased density of mesenteric fat,”
“Presence of lymph nodes,”
“Halo sign” (fat surrounding vascular structures), and
“Pseudocapsule” (dense, capsular appearance surrounding mesenteric fat).
A diagnosis of MP was made if at least three of these features were present. Each feature was scored as absent (0), mild (1), moderate (2), or marked (3), and the total severity score ranged from 3 to 15. MP severity was classified as mild (3–5), moderate (5–9), or severe (10–15).

Statistical Analysis

No a priori power analysis was performed because this study was designed as a retrospective analysis of all eligible cases within the specified time frame, and the sample size was determined by the availability of complete data rather than pre-study calculations. Data collected during the study were analyzed using IBM SPSS 20.0 (Chicago, IL, USA) statistical software.

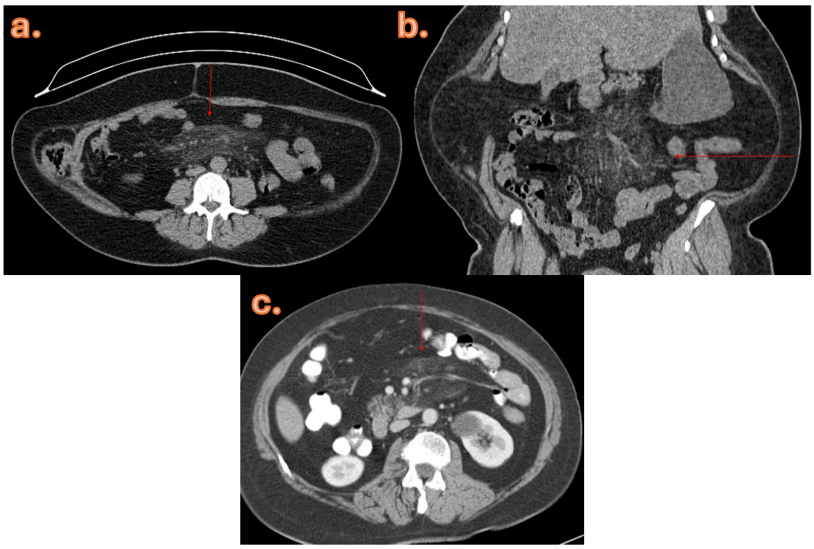

Figure 1: a:-**Mesenteric fat stranding with lymph nodes exhibiting a capsular appearance and surrounding halo in a female patient presenting with abdominal pain, observed in the midline. b-c: Abdominal CT images in axial and coronal planes, performed due to a history of nephrolithiasis, demonstrating marked mesenteric fat stranding and mild mass effect on the adjacent bowel loops.**

Results

A total of 122 patients were diagnosed with MP using the scoring system during the study period. However, 42 patients were excluded due to missing data, resulting in a final sample size of 80 patients **(Figure 2).**

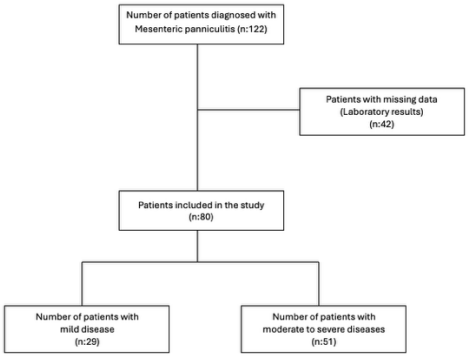

Figure 2: **Flowchart showing number of patients of the study**

Of these, 50% were female, and the median age was 59 years. The demographic and laboratory data of the patients are presented in **Table 1**.

The CT findings of the patients, along with the panniculitis severity scores, are provided in **Table 2**. The median total MP score was found to be 6. Of the patients, 36.2% were classified as having mild disease, while 63.8% had moderate-to-severe disease.

When the patients were evaluated based on the severity of MP, there were no statistically significant differences in comorbidities or systemic inflammatory parameters (NLR, PLR, SII, SIRI and AISI) (all values p>0.05). Although the density of mesenteric fat was higher compared to visceral adipose tissue, this difference was not statistically significant in relation to systemic inflammatory parameters (p>0.05) **(Table 3).**

Table 1: Demographics and laboratory data of all patients (n=80)

Gender, n (%)	
▪ Female	50 (50%)
Age, median (IQR 25-75)	59 (51-68)
Contrast-Enhanced Computed Tomography, n (%)	16 (20%)
Comorbidity, n (%)	
▪ Hypertension	28 (35%)
▪ Diabetes	23 (28.8%)
▪ Coronary artery disease	12 (15%)
▪ Chronic kidney disease	3 (3.8%)
▪ Other	13 (16.3%)
Laboratory, median (IQR 25-75)	
▪ WBC	8.23 (7.02-10.6)
▪ Neutrophil	4.83 (3.91-6.46)
▪ Lymphocyte	2.04 (1.67-2.76)
▪ Hemoglobin	14 (12.8-15.5)
▪ Platelet	252 (207-312)
Systemic inflammatory markers, median (IQR 25-75)	
▪ NLR	2.16 (1.72-3.24)
▪ SIRI	1.15 (0.74-2.02)
▪ PLR	115.4 (92.3-153)
▪ SII	602.2 (421.6-840)
▪ AISI	297.2 (185.2-563.3)

WBC: White blood cell, ***NLR***: Neutrophil lymphocyte ratio, ***SIRI***: Systemic inflammatory response index, ***PLR***: Platelet lymphocyte ratio, ***SII***: Systemic immune-inflammation index, ***AISI***: Aggregate index of system inflammation

Table 2: Abdominal computed tomography findings of patients

Mass effect, (n) %	
▪ None	12 (15%)
▪ Mild	35 (43.8%)
▪ Moderate	31 (38.8%)
▪ Severe	2 (2.5%)
Fatty tissue contamination, (n) %	
▪ None	3 (3.8%)
▪ Mild	44 (55%)
▪ Moderate	22 (27.5%)
▪ Severe	11 (13.8%)
Number of lymph nodes, (n) %	
▪ 0-9	43 (53.8%)
▪ 10-20	35 (43.8%)
▪ 21 and over	2 (2.5%)
Short dimension of largest lymph node (mm) – *median (IQR25%-75%)*	4 (4-6)
Pseudo capsule, (n) %	
▪ None	14 (17.5%)
▪ Mild	30 (37.5%)
▪ Moderate	25 (31.3%)
▪ Severe	11 (13.8%)
Fat halo sign, (n) %	
▪ None	23 (28.8%)
▪ Mild	36 (45%)
▪ Moderate	18 (22.5%)
▪ Severe	3 (3.8%)
Total MP score *median (IQR25%-75%)*	6 (4-8.7)
Total MP score severity, (n) %	
▪ Mild	29 (36.2%)
▪ Moderate	41 (51.3%)
▪ Severe	10 (12.5%)
Transverse dimension of MP area (cm) - *median (IQR25%-75%)*	7.85 (6.8-9.1)
Anteroposterior dimension of MP area (cm)- *median (IQR25%-75%)*	3.8 (3.2-4.8)
Upper-lower dimension of MP area (cm) - *median (IQR25%-75%)*	8.1 (7.1-9.5)
Average fatty tissue density of the MP area(cm) - *median (IQR25%-75%)*	-87 [(-95.6)- (-76.6)]
Fatty tissue density of MP area (cm) - *median (IQR25%-75%)*	-19.8 [(-22.8)- (-16)]
Visceral fat tissue mean density - *median (IQR25%-75%)*	-113.9 [(-117.4)- (-110)]
Visceral fat tissue density - *median (IQR25%-75%)*	-16.6 [(-19)- (-14.6)]
Additional findings that may cause abdominal pain, (n) %	
▪ Urolithiasis, without obstruction	23 (26.7%)
▪ Urolithiasis, with obstruction	18 (20.9%)
▪ Other abdominal pathologies	15 (17.4%)
▪ Concomitant intra-abdominal malignancy	3 (3.8%)

MP: Mesenteric panniculitis

Discussion

Mesenteric panniculitis is fundamentally a radiologically diagnosed condition. In this study, which investigated the changes in systemic inflammatory markers in patients with MP, we found that despite the underlying inflammation in MP, systemic inflammatory markers did not significantly vary with the severity of the disease. This suggests that in MP, inflammation may remain localized at the mesenteric level, and the absence of associated abdominal pathology results in no systemic inflammatory response.

MP is a nonspecific inflammatory pathological condition affecting the mesenteric adipose tissue of both the small and large intestines. Histologically, nearly all cases exhibit fat necrosis, chronic inflammation, and fibrosis [10]. Diagnosis is usually confirmed through CT, which reveals pathognomonic features such as pseudo capsules, fat halo sign, and fat stranding [3]. Horton et al. reported that CT findings are specific for diagnosing MP, reflecting a preserved fat ring around the mesenteric vessels and the presence of a tumoral pseudo capsule [11]. In our patients, particularly in those with moderate and severe disease, these findings were prominent. Although histopathology may be considered the gold standard for diagnosis, in most cases, patients are followed without further investigation if the condition does not progress [12, 13]. In our study, MP was diagnosed based on CT findings alone, without pathological confirmation.

In Emory's study, the incidence of MP was higher in men and more frequent in individuals aged 50-60 years [8]. However, some longitudinal studies have shown a higher incidence in women [14]. While our study involved similar age groups, no significant gender differences were found.

The pathogenic mechanism of MP appears to be a nonspecific response to various stimuli. Although numerous causal factors have been identified, the precise etiology remains unknown [1-3]. MP has been associated with a variety of underlying conditions, including rheumatologic diseases, malignancies, pancreatitis, vasculitis, granulomatous diseases, prior abdominal surgeries or trauma, ischemia, and infections [1, 13, 14]. MP may be asymptomatic or present with symptoms such as abdominal pain, constipation, and diarrhea. The majority of our patients presented with abdominal pain, and the primary diagnosis in most cases was urolithiasis. A study analyzing 3,698 consecutive CT scans of patients with MP found that metabolic syndrome, urogenital diseases, and vascular diseases were significantly more common in MP patients compared to those without the disease. In this cohort, urogenital diseases were reported in 37.3% of MP patients and 26.7% of the matched cohort [15]. It has also been suggested that MP may be associated with chronic factors such as urine leakage [3]. In 28% of our patients (n=18), obstruction was observed in the renal collecting system or ureter. However, when comparing systemic inflammatory parameters between patients with and without obstruction, no significant

Table 3: Comparison of patients according to the severity of Mesenteric Panniculitis

	Mild (n=29)	Moderate-severe (n=51)	P value
Age, *median (IQR 25-75%)*	56 (45.5-679)	60 (54-68)	0.134
Gender, n (%)			
▪ Female	14 (48.3%)	26 (51%)	0.816
Comorbidity, n (%)			
▪ Hypertension	10 (34.5%)	18 (35.3%)	0.942
▪ Diabetes	8 (27.6%)	15 (29.4%)	0.862
▪ Coronary artery disease	4 (13.8%)	8 (15.7%)	0.820
▪ Chronic kidney disease	3 (10.3%)	0 (%)	0.044
Ureteral obstruction, n (%)	6 (20.7%)	12 (23.5%)	0.770
Malignancy, n (%)	0 (0%)	3 (5.9%)	0.550
Number of lymph nodes, n (%)			
▪ 0-9	20 (69%)	23 (45.1%)	0.083
▪ 10-20	9 (31%)	26 (51%)	
▪ 21 and over	0 (0%)	2 (3.9)	
The largest short lymph node size (mm), *median (IQR 25-75%)*	4 (4-5)	4 (4-6)	0.113
Systemic inflammatory markers, *median (IQR 25-75)*			
▪ NLR	2.31 (1.66-3.46)	2.1 (1.72-3.24)	0.790
▪ SIRI	1.2 (0.74-2.1)	1.15 (0.74-2.02)	0.951
▪ PLR	115 (100.7-166.6)	118 (90.3-150.5)	0.741
▪ SII	609.4 (356.8-898.2)	595.1 (425.6-832)	0.805
▪ AISI	252.1 (188.8-611.8)	302.4 (185.1-561.3)	0.789

NLR: Neutrophil lymphocyte ratio, ***SIRI***: Systemic inflammatory response index, ***PLR***: Platelet lymphocyte ratio, ***SII***: Systemic immune-inflammation index, ***AISI***: aggregate index of systematic inflammation, ***MP***: Mesenteric panniculitis

difference was found (p>0.05 for all values). This suggests that inflammation in MP remains localized and does not induce a systemic response.

A study evaluating the relationship between MP and malignancy found that the risk of malignancy in MP patients is five times higher compared to those without mesenteric involvement, and MP is frequently observed in non-Hodgkin lymphoma [10]. In our study, malignancy was present in only three patients, and in these cases, inflammatory markers were generally within normal limits. This could be attributed to the fact that most of these patients were diagnosed with urolithiasis based on CT, and no infectious or inflammatory conditions were present other than panniculitis. Our results align with previous case series in which inflammatory markers remained within normal limits [15]. In a study by Kaya et al. evaluating 22 MP patients, the median C-reactive protein (CRP) level at diagnosis was 26.9 mg/L (range, 0.44–573 mg/L), and the mean white blood cell count was 10.690 ± 3.504/mL (normal range, 4.500–10,500/mL), with a mild increase in inflammatory markers [9]. Neutrophilia, increased erythrocyte sedimentation rate, and occasionally anemia have been reported in cases of retractile mesenteritis. Retractile mesenteritis has been associated with several malignancies, including lymphoma, lung cancer, renal cell carcinoma, colon cancer, myeloma, gastric carcinoma, chronic lymphocytic leukemia, and Hodgkin's disease [3, 15]. Our findings are consistent with previous literature indicating that systemic inflammatory markers may vary according to the presence of concomitant malignancy in patients with MP. Atacan et al., in a large retrospective study of 716 patients, reported that mean hemoglobin levels and leukocyte counts were significantly lower in the malignant group compared to the nonmalignant group, while the frequency of anemia and leukopenia was markedly higher in the malignant group. Moreover, mean ESR values and the proportion of patients with elevated ESR were significantly greater among those with malignancy [16]. These results suggest that systemic inflammatory and hematological alterations in MP are more pronounced when associated with malignant conditions. In our cohort, where malignancy was rare, systemic inflammatory parameters remained within normal limits and showed no significant correlation with disease severity, supporting the notion that MP-related inflammation may remain localized in the absence of malignancy or other inflammatory comorbidities. While these findings may be generalizable to similar tertiary care settings, differences in patient demographics and disease spectrum should be considered. Clinically, our results imply that systemic inflammatory markers may have limited diagnostic or prognostic utility for MP severity assessment in patients without underlying malignant or systemic inflammatory disorders. In our study, no correlation between the severity of panniculitis and an increase in systemic inflammatory parameters derived from CBC was observed. MP remains a chronic inflammatory condition of the mesentery with an unknown etiology, and while it is typically diagnosed through radiological methods, it can also be diagnosed in patients with no known pathology causing mesenteric inflammation, as seen in our study. In such cases, no systemic inflammatory response may be observed.

Limitations

This study is a single-center, retrospective analysis. A limitation of our study is that some demographic data (e.g., obesity, smoking) could not be obtained for some patients. In addition, in some cases not accompanied by infection (e.g., urolithiasis), tomography was performed, and the small number of patients with concomitant malignancies prevents us from drawing conclusions in this regard. Furthermore, the lack of a significant association between systemic inflammatory markers and CT severity scores may be partially explained by the limited statistical power and possible selection bias, as a notable proportion of patients underwent CT for non-inflammatory conditions such as urolithiasis. As this study employed a cross-sectional design, causal relationships between CT findings and systemic inflammatory parameters cannot be established. The observed associations should therefore be interpreted as correlational rather than causal. Another limitation is that the diagnosis of MP is based only on CT findings without pathological confirmation.

Conclusion

In conclusion, MP is a rare clinical condition that describes chronic inflammation of the mesentery, which may develop independently or in association with other diseases. MP is typically diagnosed through CT imaging, and its features have been well-defined in recent literature. In the absence of accompanying acute or chronic infectious or inflammatory pathologies, MP does not seem to significantly affect systemic inflammatory response. Further studies with larger sample sizes are needed to clarify the significance of MP and to assess systemic inflammatory responses in these patients.

Author contribution statement

All authors (SUR, İE, GK, CÖ, and YÇ) participated in the planning, writing, editing, and review of this manuscript.

Conflicts of interest and funding

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper. No funding was received for this study.

Ethical approval

This study was approved by Ataturk Sanatoryum Training and Research Hospital Ethics Committee (2023-KAEK/15-2696).

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References

1. Buragina G, Magenta Biasina A, Carrafiello G. Clinical and radiological features of mesenteric panniculitis: a critical overview. Acta Biomed. 2019;90(4):411-422.
2. Protin-Catteau L, Thiéfin G, Barbe C, Jolly D, Soyer P, Hoeffel C. Mesenteric panniculitis: review of consecutive abdominal MDCT examinations with a matched-pair analysis. Acta Radiol. 2016;57(12):1438–1444.
3. Issa I, Baydoun H. Mesenteric panniculitis: various presentations and treatment regimens. World J Gastroenterol. 2009 Aug 14;15(30):3827–30.
4. Coulier B. Mesenteric panniculitis. Mesenteric panniculitis. Part 2: prevalence and natural course: MDCT prospective study. JBR-BTR. 2011;94(5):241–6.
5. Oztan MO, Ozdemir T, Uncel M, Diniz G, Koyluoglu G. Isolated omental panniculitis in a child with abdominal pain: case report. Arch Argent Pediatr. 2016;114(6):425.
6. Emektar E, Dağar S, Karaatlı RH, Uzunosmanoğlu H, Buluş H. Determination of factors associated with perforation in patients with geriatric acute appendicitis. Ulus Travma Acil Cerrahi Derg. 2022;28(1):33-38.
7. Özen Olcay H, Emektar E, Tandoğan M, Şafak T, Bulus H, Cevik Y, et al. Evaluation of urine analysis in adults with simple and complicated appendicitis. Ankara Med J. 2020;20:790-7.
8. Emory TS, Monihan JM, Carr NJ, Sobin LH. Sclerosing Mesenteritis, Mesenteric Panniculitis and Mesenteric Lipodystrophy: a single entity. The American Journal of Surgical Pathology. 1997;21(4):392–8.
9. Kaya C, Bozkurt E, Yazıcı P, İdiz UO, Tanal M, Mihmanlı M. Approach to the diagnosis and treatment of mesenteric panniculitis from the surgical point of view. Turk J Surg. 2018;34(2):121-124.
10. Scheer F, Spunar P, Wiggermann P, Wissgott C, Andresen R. Mesenteric Panniculitis (MP) in CT - A Predictor of Malignancy? 2016;188(10):926-932.
11. Horton K.M., Lawler L.P., Fishman E.K. CT findings in sclerosing mesenteritis (panniculitis)spectrum of disease. Radiographics. 2003;23:1561–1567.
12. Ming-En Zhao, Ling-Qiang Zhang, Li Ren, Zhen-Wei Li, Xiao-Lei Xu, Hai-Jiu Wang. A case report of mesenteric Panniculitis. J. Int. Med. Res. 2019;47(7):3354–3359.
13. Daskalogiannaki M, Voloudaki A, Prassopoulos P, Magkanas E, Stefanaki K, Apostolaki E, Gourtsoyiannis N. CT evaluation of mesenteric panniculitis: prevalence and associated diseases. AJR Am J Roentgenol. 2000;174:427–431.
14. Abdelwahed Hussein Mahmoud Rezk, Abdelwahed Saad Rezk. Mesenteric panniculitis: an update. Expet Rev. Gastroenterol. Hepatol. 2015;9(1):67–78.
15. Delgado Plasencia L, Rodríguez Ballester L, López-Tomassetti Fernández EM, Hernández Morales A, Carrillo Pallarés A, Hernández Siverio N. Paniculitis mesentérica: experiencia en nuestro centro [Mesenteric panniculitis: experience in our center]. Rev Esp Enferm Dig. 2007;99(5):291-297.
16. Atacan H, Erkut M, Değirmenci F, Akkaya S, Fidan S, Coşar AM. A Single Tertiary Center 14-year Experience with Mesenteric Panniculitis in Turkey: A Retrospective Study of 716 Patients. Turk J Gastroenterol. 2023;34(2):140-147.

SANATORIUM
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Case Report

A Rare Intraoperative Complication: Venous Air Embolism During Laparoscopic Cholecystectomy – A Case Report

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Abstract

Background: Venous air embolism (VAE) is a rare but potentially fatal complication that may occur in laparoscopic procedures, particularly during the creation of pneumoperitoneum. Rapid diagnosis and intervention are essential for preventing severe outcomes.

Case Presentation: We report the case of a 24-year-old female patient who underwent elective laparoscopic cholecystectomy. Shortly after initiation of pneumoperitoneum, bradycardia, hypotension, hypoxemia, and a sudden decrease in end-tidal CO_2 developed. Immediate cessation of insufflation, placement of the patient in the Durant's position, and central venous catheterization for air aspiration were performed. Approximately 20 cc of air was aspirated, leading to rapid hemodynamic stabilization.

Conclusion: Prompt identification and management, including discontinuation of insufflation, Durant's positioning, and central venous aspiration, provided rapid hemodynamic stabilization. This case emphasizes the importance of intraoperative alertness and rapid interventions in the management of VAE.

Keywords
Venous air embolism, laparoscopy, anesthesia, insufflation, pneumoperitoneum.

Introduction

Laparoscopic cholecystectomy is a safe surgical method that is frequently performed today. Laparoscopic surgery is a minimally invasive procedure. The surgeon makes a small incision and uses thin, long instruments to examine the abdomen and perform surgery. It can be used for diagnostic or therapeutic purposes. Because laparoscopic surgery is performed through a smaller incision, it results in less scarring, a lower risk of complications, and a quicker recovery. Although the laparoscopic surgery is safer than open technique, complications such as infection and organ perforation may rarely occur [1].

Venous air embolism (VAE) is a very rare complication that can lead to serious morbidity and mortality. VAE usually occurs during the formation of pneumoperitoneum [2,3]. Careful intraoperative monitoring is vital for early diagnosis of this complication and reduction of morbidity [3-6].

In this report, a case of VAE occurred during laparoscopic cholecystectomy is discussed, and the diagnostic approach and management strategies are elaborated.

Case Presentation

A 24-year-old female patient was scheduled for elective laparoscopic cholecystectomy. The patient, without known systemic disease, was classified as ASA Physical Status I. The patient's body weight was 58 kg, height was 165 cm, and BMI was 21.3 kg/m^2.

Anesthesia Management

After the vascular access was established, she was premedicated in the preoperative period. 2 mg midazolam was administered intravenously for anxiolytic and sedation purposes. The patient, was monitored with electrocardiography (ECG), non-invasive arterial blood pressure (NIBP), and peripheral oxygen saturation (SpO_2) within the scope of standard anesthesia

monitoring in the operating room. The patient's vital signs were evaluated, and it was observed that she was hemodynamically stable.

Anesthesia induction was performed intravenously using 2 mg/kg propofol, 1-2 µg/kg fentanyl and 0.6 mg/kg rocuronium. After uneventful endotracheal intubation, correct placement of the tube was confirmed by auscultation and capnography. Intraoperative ventilator settings were adjusted as follows: the tidal volume 6-8 mL/kg of ideal body weight, the respiratory rate providing normocapnia, the fractional inspiratory oxygen concentration (FiO_2) 40-50%, and the positive end expiratory pressure (PEEP) 5 cmH_2O.

General anesthesia was maintained with desflurane, and SpO2, end-tidal CO_2 levels, and other hemodynamic parameters were in normal range.

Surgical Intervention

Pneumoperitoneum was initiated using an intra-abdominal pressure of 15 mmHg with the patient in the supine position. Following insufflation, the end-tidal CO_2 ($EtCO_2$) value dropped dramatically from 34 mmHg to 20, 15, 10, and finally 8 mmHg. Simultaneously, SpO_2 decreased to 80–85%, bradycardia (HR: 39 bpm) and severe hypotension developed. Intra-arterial cannulation was promptly performed and arterial blood gas (ABG) analysis revealed significant metabolic acidosis and elevated lactate levels **(Table 1).**

The patient was administered 20 mg ephedrine and 1 mg atropine intravenously, but no significant hemodynamic improvement was observed. A norepinephrine infusion was initiated. On auscultation, bilateral breath sounds were present. However, SpO_2 remained ≤85% despite 100% oxygen administration, and $EtCO_2$ values remained critically low. Given the clinical picture, venous air embolism (VAE) was suspected.

Insufflation was immediately ceased. While the surgical team stopped gas insufflation, the patient was placed in the Durant's position (left lateral decubitus with head down) to prevent further embolic migration from the right ventricle to the pulmonary artery. Ventilation was continued with 100% oxygen.

A central venous catheter was inserted into the right internal jugular vein, and approximately 20 mL of air was aspirated. Following aspiration, the patient's hemodynamic parameters improved rapidly.

Due to the VAE, the surgical procedure was postponed. Neuromuscular blockade was reversed with 4 mg/kg sugammadex. The patient regained spontaneous respiration and was oriented, cooperative, and responsive to verbal commands. Extubation was performed safely in the operating room.

Post-extubation ABG values **(Table 1)** demonstrated mild residual metabolic acidosis and moderate hypoxemia. Nasal oxygen support was initiated, and the patient was transferred to the recovery room. Neurological status remained stable, and hemodynamics normalized.

Under 3 L/min nasal oxygen, a repeat ABG **(Table 1)** showed improved oxygenation and stable metabolic status. The patient was transferred to the surgical intensive care unit (ICU) for further monitoring, where follow-up ABG confirmed full recovery of gas exchange parameters and lactate clearance **(Table 1).**

After the patient was admitted to the ICU, she was evaluated by the cardiology department using transthoracic echocardiography (TTE). No pathology was detected in the examination; no air was found in the right atrium and cardiac functions were observed to be normal. During the ICU, the patient's clinical condition remained stable without hemodynamic support.

Cardiac enzymes (troponin, CK-MB), renal function tests (BUN, creatinine), electrolyte levels (Na^+, K^+, Cl^-, Ca^{2+}), complete blood count, liver function tests (AST, ALT, ALP, GGT, bilirubin), and ABG were monitored at regular intervals during the postoperative period. The troponin value was determined as 250 ng/dl on the first postoperative day. In subsequent measurements, the troponin value was found to have decreased to

Table 1: Arterial blood gas analyses

ABG	pH	pCO_2 (mmHg)	pO_2 (mmHg)	SpO_2 (%)	Lactate (mmol/L)	Base Deficit (mmol/L)	HCO_3^- (mmol/L)
During Pneumoperitoneum (Crisis)	7,25	41	104	97	4,1	-8	18
After Extubation	7,3	38	67	93	2	-7	19
Recovery Room (3 L/min O2)	7,31	37	98	99	1,6	-7	19
ICU Monitoring	7,37	30	114	99	1,6	-5	19

ABG: Arterial Blood Gas , ***ICU***: Intensive Care Unit , ***SpO_2***: Peripheral Capillary Oxygen Saturation

normal limits as 125-115-64-13 ng/dl, respectively.

In the patient's laboratory controls, no significant change was detected compared to the preoperative values, except for troponin, and they remained within normal limits.

The patient was followed in the ICU for 2 days. During this period, she was found to be stable in neurological and respiratory evaluations.

The patient was then transferred to the ward. No postoperative complications were observed, and the patient was discharged uneventfully after the final evaluations on the third postoperative day.

Informed consent was obtained from the patient for the case to be presented.

Discussion

VAE is among the rare but serious complications of laparoscopic surgery. It occurs when gas enters the systemic venous circulation, especially during the creation of pneumoperitoneum, during trocar insertion or when open venous structures are encountered during insufflation [3,5,6].

In this case, the sudden $EtCO_2$ drop, bradycardia, hypotension and hypoxemia at the beginning of surgery constituted the classic findings of VAE. A sudden and dramatic decrease in $EtCO_2$, reflecting a sudden decrease in pulmonary perfusion, may be the earliest and most sensitive indicator of gas embolism. Although such a change is not highly specific, it is quite valuable for diagnosis, especially when seen during the surgical insufflation period.
One of the most reliable methods for diagnosing VAE is transesophageal echocardiography (TEE) [3,4]. It has been reported that even asymptomatic, subclinical embolism can be detected with TEE at a rate of 76-100%. However, TEE is not routinely used intraoperatively in most surgical centers. Therefore, careful monitoring of parameters such as $EtCO_2$, SpO_2, ECG, and arterial blood pressure is vital for the anesthesiologist.

In this case, the decrease in $EtCO_2$ to 8mmHg within a few seconds immediately after surgical insufflation and the development of hemodynamic instability with hypoxemia quickly suggested the diagnosis of VAE. One of the classical maneuvers that can be applied in this situation, the Durant's position (head down and left lateral position), aims to prevent the air entering the right atrium from passing into the pulmonary circulation (6). In this patient, the surgeon's termination of insufflation and placing the patient in the head up position were sufficient to stop the progression of the air embolism. Rapid intervention with central catheter placement through the internal jugular vein and air aspiration was life-saving in this case. Air bubbles seen during aspiration supported the accuracy of the diagnosis. The normalization of the patient's hemodynamic parameters in a short time demonstrated the effectiveness of the applied treatment strategies.

In the literature, serious complications of VAE include cardiac arrest, brain damage, permanent neurological sequelae, and death [6-11]. In particular, early intubation, ventilation with 100% oxygen, immediate cessation of insufflation, and venous air aspiration are the cornerstones of effective management. In this case, rapid diagnosis and effective interventions prevented the development of severe complications.

Conclusion

A clinical presentation with a sudden decrease in $EtCO_2$, bradycardia, hypotension and hypoxemia should suggest VAE and immediate interventions should be initiated. Appropriate interventions including cessation of surgical insufflation, ventilation with 100% oxygen, appropriate change of patient position and central venous air aspiration might be lifesaving as in the present case.
We thought that the complication was successfully managed with timely and effective interventions without development of cardiac arrest in this case.
This case report highlights the importance of intraoperative awareness and prompt interventions for rare but life-threatening complications.

Author contribution statement
All authors (ED, SK, BA, MÖC, MB, HS) participated in the planning, writing, editing, and review of this manuscript.

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References

1. Buia A, Stockhausen F, Hanisch E. Laparoscopic surgery: A qualified systematic review. World J Methodol. 2015 Dec 26;5(4):238-54. doi: 10.5662/wjm.v5.i4.238.
2. Park Kwon JY, Kim KJ. Carbon dioxide embolism during laparoscopic surgery. Yonsei Med J. 2012 May;53(3):459-66. doi: 10.3349/ymj.2012.53.3.459.
3. Schlimp CJ, Loimer T, Rieger M, Lederer W. Venous air embolism during surgery: detection and management. Minerva Anestesiol. 2020;86(2):202–211
4. Mirski MA, Lele AV, Fitzsimmons L, Toung TJK. Diagnosis and treatment of vascular air embolism. Anesthesiology. 2007;106(1):164–77. doi:10.1097/00000542-200701000-00026
5. Muth CM, Shank ES. Gas embolism. N Engl J Med. 2000;342(7):476–82. doi:10.1056/NEJM200002173420706
6. McCarthy CJ, Behravesh S, Naidu SG, Oklu R. Air embolism: diagnosis, clinical management and outcomes. Diagnostics (Basel). 2017;7(1):5. doi:10.3390/diagnostics7010005
7. Davolio MC, Pizzirani M, Vecchio S, et al. Medico-legal implications for carbon dioxide embolism during laparoscopic surgery: Two fatal cases. Forensic Science International: Reports.2023 p. 100304 . doi: 10.1016/j.fsir.2022.100304
8. Shin HY, Kim DW, Kim JD, et al. Paradoxical carbon dioxide embolism during laparoscopic cholecystectomy as a cause of cardiac arrest and neurologic sequelae: a case report. Korean J Anesthesiol. 2014 Dec;67(6):425-8. doi: 10.4097/kjae.2014.67.6.425. Epub 2014 Dec 29.
9. Lantz PE, Smith JD. J Fatal carbon dioxide embolism complicating attempted laparoscopic cholecystectomy-case report and literature review. Forensic Sci. 1994 Nov;39(6):1468-80.
10. Uchida S, Yamamoto M, Masaoka Y, Mikouchi H, Nishizaki Y. A case of acute pulmonary embolism and acute myocardial infarction with suspected paradoxical embolism after laparoscopic surgery. Heart Vessels. 1999;14:197–200. doi: 10.1007/BF02482307.
11. Shimizu K, Usuda M, Kakizaki Y, et al. Cerebral infarction by paradoxical gas embolism detected after laparoscopic partial hepatectomy with an insufflation management system: a case report. surg case rep 2023;9:34. https://doi.org/10.1186/s40792-023-01611-0

SANATORIUM
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Case Report

Serotonin Syndrome After Alcohol and Methamphetamine Ingestion in a Patient on Escitalopram: Case Presentation

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Abstract

Background: Serotonin syndrome is a rare but potentially life-threatening condition characterized by excessive serotonergic activity. This report describes a case of SS in a patient undergoing long-term escitalopram therapy who developed symptoms following the ingestion of methamphetamine and alcohol.

Case Presentation: A 42-year-old male on escitalopram presented with agitation, confusion, myoclonic movements, and a localized rash after methamphetamine and alcohol ingestion. Vital signs showed mild hypertension, low-grade fever, and hypoxemia; labs and ECG were normal. He improved rapidly with fluids, diazepam, and paracetamol, and was discharged after observation.

Conclusion: Clinical presentation included agitation, spontaneous clonus, and an unusual bullous skin lesion. Prompt supportive treatment led to symptom resolution, and the patient was discharged within six hours. This case underscores the importance of clinical vigilance for SS, particularly in patients with concurrent substance use and stable antidepressant therapy.

Keywords
Serotonin syndrome, escitalopram, methamphetamine, alcohol, bullous lesion.

Introduction

Serotonin syndrome (SS) is an increasingly recognized toxidrome in emergency medicine, often triggered by serotonergic medications widely used in psychiatric practice. Its clinical spectrum ranges from mild symptoms to severe, life-threatening manifestations, and it is most frequently precipitated by the use of serotonergic agents such as selective serotonin reuptake inhibitors (SSRIs), serotonin-norepinephrine reuptake inhibitors (SNRIs), monoamine oxidase inhibitors (MAOIs), and various antiemetic medications [1].

The diagnosis of SS is clinical and necessitates a high index of suspicion. A thorough patient history and detailed physical examination are essential for timely identification. However, the exact threshold at which serotonergic medications induce toxicity remains poorly defined [2].
Although most reported cases are associated with overdose or the combination of multiple serotonergic agents, instances involving the concomitant use of SSRIs with substances such as methamphetamine and alcohol are infrequently described [3]. Moreover, the occurrence of bullous skin lesions in the context of SS is particularly uncommon in the existing literature [4].

In this report, we describe a case of serotonin syndrome in a patient receiving long-term escitalopram therapy, who developed clinical symptoms following the ingestion of methamphetamine and alcohol, accompanied by a sterile bullous skin lesion. This case underscores an atypical presentation of SS and may contribute to the recognition of less conventional clinical scenarios associated with serotonergic toxicity.

Case Presentation

A 42-year-old male with a history of depression, on escitalopram 10 mg/day for 6 months, presented to the emergency

department with restlessness, upper extremity twitching, and redness over the right shoulder. His relatives reported that he had ingested 200 mL of beer and an unknown quantity of methamphetamine approximately four hours before presentation.

On arrival, vital signs were blood pressure 150/80 mmHg, heart rate 97 bpm, temperature 37.7°C, and oxygen saturation 92%. Electrocardiography showed normal sinus rhythm with normal QT and QRS intervals.

On physical examination, the patient appeared confused, agitated, and restless. Myoclonic movements were noted in the arms. Pupils were dilated with preserved light reflexes. Neurological exam revealed no motor or sensory deficits. A 5×5 cm maculopapular rash with a central sterile bulla was observed on the right shoulder **[Figure 1].** Other systemic examinations were unremarkable.

Figure 1: Lesions on the right shoulder

Laboratory tests including renal and liver function tests, electrolytes, blood gases, complete blood count, and troponin were within normal limits.

He was treated with intravenous fluids (2000 mL isotonic saline), 10 mg diazepam, and 1000 mg paracetamol. Symptoms improved within hours: fever resolved to 36.2°C, and myoclonus subsided. He was discharged after 6 hours of observation.

Written informed consent was obtained from the patient for publication of this case report and the accompanying image.

Discussion

Although serotonin syndrome is a well-characterized entity, its clinical presentation can be diverse and occasionally unpredictable, necessitating a high degree of diagnostic vigilance. It is a potentially life-threatening condition resulting from excessive serotonergic activity in the central nervous system [2]. The diagnosis is clinical, and the Hunter Serotonin Toxicity Criteria are widely regarded as the most specific and reliable tool for confirming the diagnosis [5]. In this case, the presence of spontaneous clonus and agitation in a patient on long-term escitalopram therapy fulfilled these criteria and strongly supported the diagnosis of SS.

Although SS typically occurs shortly after the initiation or dose escalation of serotonergic agents, it can also result from interactions with other substances [6]. In our case, the patient had been on a stable dose of escitalopram for six months without prior adverse effects. However, symptoms emerged shortly after the ingestion of methamphetamine and alcohol. While methamphetamine is not classically categorized as a serotonergic agent, it may increase serotonin levels indirectly and has been implicated in previous SS cases [3]. The role of alcohol, particularly in small quantities, remains unclear; nonetheless, its potential contribution as a co-factor cannot be entirely ruled out. We propose that the interaction between escitalopram and these substances likely precipitated the onset of serotonin syndrome in this patient, despite the absence of recent changes to SSRI therapy.

Multiple differential diagnoses were considered in this case, including neuroleptic malignant syndrome (NMS), malignant hyperthermia, sympathomimetic toxicity, anticholinergic syndrome, and thyroid storm. However, the rapid onset of symptoms, the presence of spontaneous clonus and agitation, and the absence of muscle rigidity made serotonin syndrome the most probable diagnosis. Unlike NMS, SS typically presents with hyperreflexia rather than rigidity and manifests within hours of exposure, findings that were consistent with this patient's clinical course [4]. In the absence of a definitive diagnostic marker, thorough history-taking and detailed physical examination remain essential components of clinical assessment.

The patient received supportive management, including intravenous fluid resuscitation and sedation with diazepam. Paracetamol was administered for symptomatic relief of elevated temperature, although its utility in SS is limited due to the non-hypothalamic mechanism of hyperthermia [4]. Clinical improvement was observed within hours of treatment initiation, and

the patient remained stable throughout a six-hour observation period. Intensive care monitoring was not required, and he was discharged in good condition.

A notable feature in this case was the presence of a bullous skin lesion. While not typically associated with SS, similar dermatologic manifestations have been reported in rare instances involving escitalopram use and SS [4,7,8]. The etiology of the lesion remains uncertain; it may have been incidental, drug-related, or a cutaneous expression of systemic toxicity. This case highlights the importance of clinical vigilance and suggests that SS may occasionally present with atypical features, potentially complicating the diagnostic process.

Conclusion

Given that serotonin syndrome (SS) is a clinically diagnosed condition with potentially fatal outcomes if unrecognized, maintaining a high index of suspicion in patients receiving serotonergic agents is critical. Prompt identification and early intervention are essential to minimize morbidity and prevent mortality. This case underscores the need for clinical vigilance and expands the spectrum of known SS triggers.

Author contribution statement

All authors (ZSÖ, HÖO, YÇ) participated in the planning, writing, editing, and review of this manuscript.

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References

1. Mikkelsen N, Damkier P, Pedersen SA. Serotonin syndrome-A focused review. Basic Clin Pharmacol Toxicol. 2023 Aug;133(2):124-129.
2. Chiew AL, Buckley NA. The serotonin toxidrome: shortfalls of current diagnostic criteria for related syndromes. Clin Toxicol (Phila) 2022; 60:143.
3. Suzuki A, Otani K. Serotonin Syndrome After an Alcohol Intake in a Patient Treated With Escitalopram and Clomipramine. Clin Neuropharmacol. 2019;42(3):103-104.
4. Dağar S, Emektar E, Tandoğan M, Çorbacıoğlu ŞK, Uzunosmanoğlu H, Çevik Y. A Rare Cause of Serotonin Syndrome: Chronic Olanzapine Use. Eurasian J Tox. July 2019;1(2):65-68.
5. Dunkley EJ, Isbister GK, Sibbritt D, Dawson AH, Whyte IM. The Hunter Serotonin Toxicity Criteria: simple and accurate diagnostic decision rules for serotonin toxicity. QJM. 2003;96(9):635-42.
6. Mason PJ, Morris VA, Balcezak TJ. Serotonin syndrome. Presentation of 2 cases and review of the literature. Medicine (Baltimore). 2000;79(4):201-9.
7. Caccavale S, Mea EE, La Montagna M. Bullous pemphigoid induced by escitalopram in a patient with depression. G Ital Dermatol Venereol. 2016 Feb;151(1):122-3.
8. Koylu R, Dundar ZD, Koylu O, Akinci E, Akilli NB, Gonen MO, Cander B. The experiences in a toxicology unit: a review of 623 cases. J Clin Med Res. 2014;6(1):59 65

SANATORIUM
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Case Report

Sever's Disease (Calcaneal Apophysitis): Case Report

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Abstract

Background: Calcaneal apophysitis or Sever's disease (SD) is the most common cause of heel pain in children. It is especially common in physically overactive and fast-growing children.

Case Presentation: A 12-year-old male patient who had pain in both heels for the last four months presented with increasing pain in the previous month and aggravated after sports activities. The pain in the right heel was more than in the left and prevented it from walking. Sever's disease was diagnosed by examination and radiological findings.

Conclusion: SD is a common cause of heel pain in children of growing age. It is benign and has the capacity to heal spontaneously. However, greater awareness of clinical diagnosis is important to reduce the rates of unnecessary radiological examinations.

Keywords
Serotonin syndrome, escitalopram, methamphetamine, alcohol, bullous lesion.

Introduction

Dermoid Calcaneal apophysitis (CA) or Sever's disease (SD) is a common condition in pediatric and adolescent patients with heel pain [1]. This disease is an overuse syndrome first described by James Warren Sever in 1912 [2]. The main pathology is recurrent microtrauma, which induces calcaneal apophysis damage [3]. This disease is seen in 8-13 years old girls and 11-15 years old boys [4]. SD is related to activities such as football, where there are many running and jumping movements, and activities exacerbate symptoms [5]. Anamnesis and physical examination are usually sufficient for diagnosis. Magnetic resonance imaging (MRI) is recommended to exclude suspicious cases such as fractures, tumors, or infections [1].

In this case had bilateral heel pain that had been aggravated after running and jumping and had been ongoing for four months. In addition, right heel pain caused walking difficulties. SD was diagnosed.

Case Presentation

Twelve-year-old boy. He applied to the orthopedic clinic with the complaint of bilateral heel pain. Pain in the right heel was more than in the left. This pain started 4 months ago. It has been exacerbated in the last 1 month. In addition, when he was running and jumping, the pain got worse. There was no history of trauma. In addition, there was no weight loss, fever, chronic disease, or allergy. His general condition was good, active, height 155 cm (75th percentile), weight 45 kg (50th percentile), and blood pressure was 95/60 mm Hg. Vital findings were normal. In her physical examination, he had painful walking and tenderness of the calcaneus posterior in both toes. All other system examinations were natural. The patient's erythrocyte sedimentation rate, alkaline phosphatase, and serum calcium level were normal.

Calcaneal apophysis was fragmented and sclerosis on the right lateral ankle radiograph **(Figure 1).** In MRI, calcaneal apophysis was observed with hypointense

in T1AG, hyperintense in T2AG, bone marrow edema, and microfracture. In addition, there were areas of bone marrow edema in trauma in the talus, navicular bone, cuneiform bone, in the distal part of the tibia **(Figure 2).**

SD was diagnosed. It was suggested to pause sports activities and to do stretching and strengthening movements of the gastrocnemius muscle. Nonsteroidal anti-inflammatory drugs were given for four weeks. The informed consent form was obtained from the patient.

Figure 1: In the calcaneal apophysis, sclerosis, and fragmentation seen on direct radiography are observed.

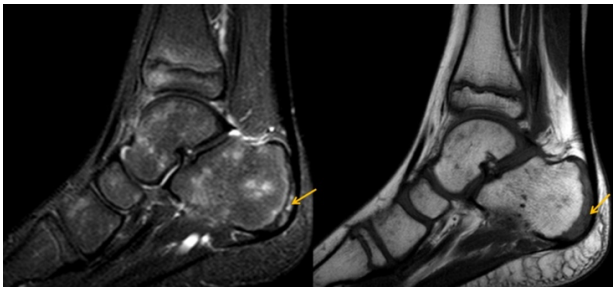

Figure 2: Magnetic resonance images showed hypointense in T1 AG, hyperintense in T2AG, bone marrow edema, and microfracture. In addition, there are patchy bone marrow edema areas in other bone structures in the study area.

Discussion

SD is aseptic necrosis due to a blood supply disorder of the growth plate located behind the calcaneus [1]. CA is common in children with heel pain. In the general population, the incidence of 4-year CA was approximately 0.35%[4]. SD initially suggested that this disease occurs in inactive and overweight children [2]. Then, high activity levels and obesity have been identified as risk factors [4].

This condition is 2-3 times more common in boys than in girls, it is bilateral in 60% of cases [4]. Repetitive running and jumping movements begin to pull the place where the Achilles tendon adheres to the bone and cause microtrauma in this region [6]. CA has a self-limiting, benign nature [7]. The prognosis of the disease is quite good and the patient can return to all activities. Symptoms typically resolve after the fusion of apophysis and calcaneus [2]. The inflammatory process rarely results in apophysis fracture [4].

The most important symptom of calcaneal apophysitis is heel pain that does not spread to the posterior of the calcaneal. The pain is localized on the back and plantar side of the heel. Pain increases with activities such as walking, running, or jumping and decreases at rest. Pain causes limping during physical activity and activity may not be performed [8]. Generally, ankle dorsiflexion loss occurs [9]. Sensitivity is revealed by pressing the heel in the back area and it is called the "spin test". Pain may occur in this region due to stretching of the Achilles tendon during walking by pressing the fingertip[10].

Ankle radiographs are generally normal in the early period [6]. In the following period, on direct radiography, calcaneal apophysis loses its homogeneity, and becomes irregular, and its density and sometimes fragmentation are observed. Fragmented or sclerotic calcaneal apophysis are two important main findings for radiological diagnosis. However, these findings are not pathognomonic for CA and can also be seen in healthy children [4]. The diagnosis of SD is made primarily based on clinical findings and anamnesis, and direct radiography is used to exclude other potential pathologies [11]. MRI examination may also be useful for this purpose. In CA, MRI findings are limited to bone marrow edema in most cases, and enhancement may occur after intravenous gadolinium use [11].

Retrocalcaneal bursitis, stress fracture, osteomyelitis, Achilles tendinitis, plantar fasciitis, and calcaneal cyst that may cause heel pain should be considered in the differential diagnosis [11]. With a good clinical evaluation, all of these causes can be excluded [9].

Conservative treatment is commonly used in the treatment of CA. The application of ice, saving this area from the load, avoiding sports, using soft insoles on the heel, stretching, and strengthening movements of the gastrocnemius-soleus muscle complex are recommended treatment methods [4]. In addition to heel supportive and stretching exercises, it has reported good results with 3 weeks of ibuprofen and topical diclofenac treatment [9]. Oral NSAIDs, short-leg fixation patches, and local ketoprofen gel application have also been reported to be beneficial [4].

The condition is self-limiting with a brief limitation of activity sometimes being advocated [12]. Sever's disease resolves with maturation and closure of the apophysis. There is no indication for operative management in Sever disease. Although the recurrence of Sever's disease is relatively common, symptoms are typically anticipated to resolve after the

closure of the apophysis. Symptoms should not be expected to persist after the patient reaches skeletal maturity [13].

Conclusion

SD is a common cause of heel pain in children of growing age. It is benign and has the capacity to heal spontaneously. However, greater awareness of clinical diagnosis is important to reduce the rates of unnecessary radiological examinations.

Author contribution statement

All authors (VK, HK) participated in the planning, writing, editing, and review of this manuscript.

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Informed consent was obtained from the patient for the case to be presented.

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References

1. Wiegerinck JI, Yntema C, Brouwer HJ, Struijs PA. Incidence of calcanealapophysitis in the general population. Eur J Pediatr. 2014;173(5):677–699. doi:10.1007/s00431-013-2219-9
2. Sever J. Apophysis of oscalcis. NY State J Med. 1912;95:1025.
3. James AM, Williams CM, Haines TP. Effectiveness of footwear and foot orthoses for calcaneal apophysitis: a 12-month factorial randomised trial. Br J Sports Med. 2016;50(20):1268-1275. doi: 10.1136/bjsports-2015-094986.
4. Ceylan, H.H., Caypinar, B. Incidence of calcaneal apophysitis in Northwest Istanbul. BMC Musculoskelet Disord 19, 267 (2018). doi: 10.1186/s12891-018-2184-6
5. Abdelgawad A, Naga O. Foot. In: Abdelgawad A, Naga O, editors. A Handbook for Primary Care Physicians, Pediatric Orthopedics. 2014 ed. New York. CN: Springer Science+Business Media; p. 157-197. 2014.
6. Kose O. Do we really need radiographic assessment for the diagnosis of non-specific heel pain (calcaneal apophysitis) in children? Skeletal Radiol. 2010;39(4):359-61. doi: 10.1007/s00256-009-0774-y.
7. Orava S, Virtanen K. Osteochondroses in athletes. Br J Sports Med. 1982;16(3):161–168. doi: 10.1136/bjsm.16.3.161
8. Cassas KJ, Cassettari-Wayhs A. Childhood and adolescent sports-related overuse injuries. Am Fam Physician. 2006;73(6):1014-1022.
9. Karahan YA, Salbaş E, Tekin L, Yaşar O, Küçük A. Sever Hastalığı: Çocuklarda topuk ağrısının önemli bir nedeni; Olgu Sunumu. Turk J Osteoporos/Turk Osteoporoz Dergisi. 2014;20(2):86-88. https://doi.org/10.4274/tod.04695.
10. Madden CC, Mellion MB. Sever's disease and other causes of heel pain in adolescents. Am Fam Physician. 1996 ;54(6):1995-2000.
11. Lawrence DA, Rolen MF, Morshed KA, Moukaddam H. MRI of heelpain. AJR Am J Roentgenol. 2013;200(4):845–855.doi: 10.2214/AJR.12.8824
12. Perhamre S, Lundin F, Norlin R, Klässbo M. Sever's injury; treat it with a heel cup: a randomized, crossover study with two insole alternatives. Scand J Med Sci Sports. 2011;21(6):e42-7.doi: 10.1111/j.1600-0838.2010.01140.x
13. Smith JM, Varacallo MA. Sever Disease (Calcaneal Apophysitis) [Updated 2024 Jan 11]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK441928/.

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Annex 1. Summary of Responses to Survey Questions

Question	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
1	29 (%14.4)	66 (%32.2)	27 (%13.4)	51 (%25.2)	29 (%14.4)
2	8 (%4)	24 (%11.9)	22 (%10.9)	96 (%47.5)	52 (%25.7)
3	9 (%4.5)	21 (%10.4)	6 (%3)	75 (%37.1)	91 (%45)
4	50 (%24.8)	50 (%24.8)	12 (%5.9)	35 (%17.3)	55 (%27.2)
5	28 (%13.9)	67 (%33.2)	26 (%12.9)	51 (%25.2)	30 (%14.9)
6	5 (%2.5)	14 (%6.9)	16 (%7.9)	95 (%47)	72 (%35.6)
7	0 (%0)	4 (%2)	2 (%1)	57 (%28.2)	139 (%68.8)
8	7 (%3.5)	36 (%17.8)	34 (%16.8)	71 (%35.1)	54 (%26.7)
9	32 (%15.8)	93 (%46)	39 (%19.3)	29 (%14.4)	9 (%4.5)
10	15 (%7.4)	79 (%39.1)	34 (%16.8)	37 (%18.3)	37 (%18.3)
11	11 (%5.4)	29 (%14.4)	19 (%9.4)	98 (%48.5)	45 (%22.3)
12	9 (%4.5)	19 (%9.4)	15 (%7.4)	98 (%48.5)	61 (%30.2)
13	3 (%1.5)	16 (%7.9)	5 (%2.5)	91 (%45)	87 (%43.1)
14	2 (%1)	12 (%5.9)	15 (%7.4)	76 (%37.6)	97 (%48)
15	0 (%0)	0 (%0)	2 (%1)	59 (%29.2)	141 (%69.8)
16	1 (%5)	6 (%3)	8 (%4)	51 (%25.2)	136 (%67.3)
17	0 (%0)	0 (%0)	0 (%0)	37 (%18.3)	165 (%81.7)

ANNEX-2: Survey Questionnaire

Which of the following statements is true for your clinic?

a) The PECARN algorithm is used in our clinic.

b) The decision for CT imaging is made by the physician.

Please indicate your level of agreement with each of the following statements by selecting one of the options: Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree.

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. I request an immediate CT scan in patients with scalp hematoma, regardless of age.	☐	☐	☐	☐	☐
2. In patients with scalp hematoma, I decide on CT based on age and post-observation clinical findings.	☐	☐	☐	☐	☐
3. I immediately request a CT	☐	☐	☐	☐	☐

scan in patients with a Glasgow Coma Scale (GCS) score <15.					
4. In patients with GCS <15, I consider CT after 2-hour observation if clinical deterioration occurs.	☐	☐	☐	☐	☐
5. If the patient reports a headache following trauma, I immediately order a CT scan.	☐	☐	☐	☐	☐
6. I order a CT scan if the patient's headache worsens after 2 hours of observation.	☐	☐	☐	☐	☐
7. I immediately order a CT scan in case of altered mental status after trauma.	☐	☐	☐	☐	☐
8. If the patient's family demands CT imaging in pediatric head trauma, I comply and order CT.	☐	☐	☐	☐	☐
9. Family request for CT imaging does not affect my clinical decision-making.	☐	☐	☐	☐	☐
10. I immediately order a CT scan if the patient vomits once after trauma.	☐	☐	☐	☐	☐
11. I prefer to observe the	☐	☐	☐	☐	☐

patient after a single vomiting episode and order CT only if additional symptoms develop.					
12. The age of the patient (under or over 2 years) affects my CT decision-making process.	☐	☐	☐	☐	☐
13. In patients over 2 years of age, I order immediate CT for any reported change in consciousness.	☐	☐	☐	☐	☐
14. Concern about malpractice and overcrowding in the ED is an important factor in my CT decision.	☐	☐	☐	☐	☐
15. I order immediate CT if the patient experiences a seizure after trauma.	☐	☐	☐	☐	☐
16. I order immediate CT in the presence of signs suggestive of a non-depressed skull fracture.	☐	☐	☐	☐	☐
17. I order immediate CT in the presence of signs suggestive of a basilar skull fracture.	☐	☐	☐	☐	☐

Age	
Gender	
Years of medical practice	
The clinic where you are currently working actively	