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IMAGING METHODS USED IN THE DIAGNOSIS OF GASTROINTESTINAL PERFORATION AND IMAGING FINDINGS

GASTROİNTESTİNAL PERFORASYON TANISINDA KULLANILAN GÖRÜNTÜLEME YÖNTEMLERİ VE GÖRÜNTÜLEME BULGULARI

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Abstract

Aim: To evaluate the imaging methods used in patients diagnosed with gastrointestinal perforation (GIP) and the contribution of these methods to the diagnosis.

Methods: Preoperative radiological examinations of 73 patients 18 years old or older whose surgical results indicated GIP were retrospectively evaluated. The perforation sites were divided into 4 groups, namely the first segment of the gastroduodenum, part of the small intestine beginning with the second segment of the duodenum, the colorectum, and the appendix. Esophageal perforations were considered as a separate group and excluded from the study.

Results: Fifty-two (71.2%) of the patients were male. The mean age of the patients was 45.1±18.2 years with a range of 18-87 years. Forty (54.8%) patients had perforations of the appendix and 25 (34.2%) patients had perforations of the gastroduodenum. Computed tomography (CT) was performed in 56 (76.7%) of the patients, ultrasonography (USG) in 55 (75.3%), and radiography (RG) in 48 (65.8%). The evaluation of RG images of the patients for the presence of subdiaphragmatic free air showed that 50% of the patients with non-appendix perforations had subdiaphragmatic free air. The most common findings in the USG results of the patients with appendix perforations were an increase in the diameter and heterogeneity of mesenteric fatty tissue, while the most common USG finding in the patients with the other perforations was free fluid. The site of perforation was accurately determined in 83.9% of the patients diagnosed with non-appendix perforations by CT.

Conclusions: CT is the most preferred imaging modality and has the most diagnostic value in the diagnosis of GIP. It is also useful in determining the perforation site.

Keywords: Gastrointestinal tract, perforation, imaging

Öz

Amaç: Bu çalışmanın amacı gastrointestinal perforasyon (GIP) tanısı konulan hastalarda kullanılan görüntüleme yöntemlerini ve bu yöntemlerin tanıya katkısını değerlendirmektir.

Yöntemler: Çalışmamızda operasyon sonuçları GIP olarak belirtilen 18 yaş ve üzeri 73 hastanın operasyon öncesi radyolojik tetkikleri retrospektif olarak değerlendirildi. Perforasyon bölgeleri mide-duodenum birinci kesimi, duodenum ikinci kesimi başlangıcından itibaren ince barsak, kolorektal ve apendiks olarak 4 gruba ayrıldı. Özofagus perforasyonları ayrı bir grup olarak düşünülüp çalışma dışı bırakıldı.

Bulgular: Hastaların 52 (%71,2) si erkekti. Yaşları 18 ile 87 arasında olup ortalama yaşları 45,1±18.2 bulundu. 40(%54,8) hastada apendiks perforasyonu, 25(%34,2) hastada mide-duodenum perforasyonu vardı. 56 (%76,7) hastaya bilgisayarlı tomografi (CT), 55 (%75,3) hastaya ultrasonografi (USG) ve 48(%65,8) hastaya radyografi (RG) tetkiki yapılmıştı. Hastaların RG'leri subdiyafragmatik serbest hava varlığı açısından değerlendirildiğinde apendiks dışı perforasyonu olan hastaların %50 sinde subdiyafragmatik serbest hava görüldü. Apendiks perforasyonu olan hastaların USG'lerinde en sık tanımlanan bulgular çap artışı ve mezenterik yağlı dokuda heterojenite iken diğer perforasyonlarda en sık USG bulgusu serbest sıvıydı. CT ile apendiks dışı perforasyonu olan hastaların %83,9'unda perforasyon yeri doğru olarak belirlendi.

Sonuç: Çalışmamızda GIP tanısı konulurken en fazla tercih edilen ve tanısal değeri en yüksek olan görüntüleme modalitesinin CT olduğunu saptadık. Ek olarak CT perforasyon yerini belirlemede de faydalıydı.

Anahtar Kelimeler: Gastrointestinal sistem, perforasyon, görüntüleme

Introduction

Gastrointestinal perforation (GIP) is a surgical emergency. It can occur due to peptic ulcer, blunt or penetrating trauma, inflammatory bowel disease, iatrogenic factors, neoplasm, or foreign bodies[1]. Currently, laparoscopic methods are used instead of conventional laparotomy in appropriate cases depending on the site and cause of perforation[2-3]. Therefore, along with the diagnosis of perforation, it is important to determine the site and cause of the perforation and other accompanying findings.

The most preferred imaging method for diagnosing suspected GIP is radiography (RG). Along with abdominal RG, standing lung RG may also be performed for this purpose. Extraluminal air may be seen in these radiographs. However, if the perforation is too small or closes spontaneously, extraluminal air may not be seen. The sensitivity of RG regarding detection of extraluminal air varies from 50% to 70%[4-5]. Ultrasonography (USG) does not play a major role in the diagnosis of GIP. However, in patients with localized abdominal symptoms, USG can be used for differential diagnosis[6.] USG may help show the presence of pneumoperitoneum and pneumoretroperitoneum as direct findings and free fluid and thickened bowel segments as indirect findings[7]. Currently, the preferred imaging method used in patients with suspected GIP is computed tomography (CT). CT is also useful for determining the site and cause of perforations[8-11].

The aim of the present study was to evaluate the imaging methods used in patients diagnosed with GIP and the contribution of these methods to the diagnosis.

Materials and Methods

In this retrospective study, patients 18 years old or older whose surgical results indicated GIP between 01.01.2021 and 03.31.2022 were listed using the hospital information processing system and all patients (73 patients) were included in the study. The perforation sites were divided into 4 groups, namely the first segment of the gastroduodenum, part of the small intestine beginning with the second segment of the duodenum, the colorectum, and the appendix. Esophageal perforations were considered as a separate group and excluded from the study. The radiological images of the patients were evaluated by a radiologist via the hospital imaging archive system. Since appendix perforations may have some specific signs, the radiologist was informed about patients suffering from these. However, the cause and site of the other perforations were not known by the radiologist. RG images were evaluated for presence of extraluminal air. Figure 1 shows an RG image of subdiaphragmatic free air.

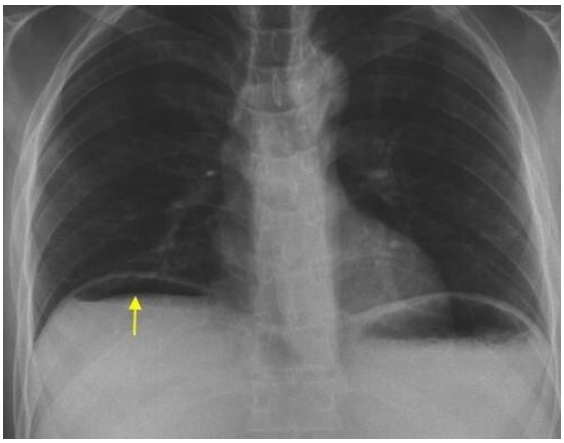

Figure 1. The radiography of a patient with gastroduodenal perforation; the arrow shows subdiaphragmatic free air.

CT images were evaluated for findings of free air, free fluid, mural thickening, mural contrast, mural discontinuity and fat stranding in the non-appendix perforations. Figure 2 shows a CT image of free air and mural discontinuity. Diameters, mucosal hyperenhancement, mucosal defect, periappendiceal air, periappendiceal fluid, fat stranding, appendicoliths, and abscess

findings in appendix perforation were evaluated. Figure 3 shows a CT image of an appendicolith and fat stranding.

- *Statistical analysis*

The statistical analysis was performed using SPSS v.22 (SPSS Inc. Chicago, IL, USA). The means and standard deviations of the continuous variables and the number and percentage values of the categorical data were calculated. In order to compare the groups, the chi-square test was performed. The level of statistical significance was set at $p<0.05$.

Figure 2. The axial CT image of a patient with gastroduodenal perforation; the arrowhead shows free air and the arrow shows mural discontinuity.

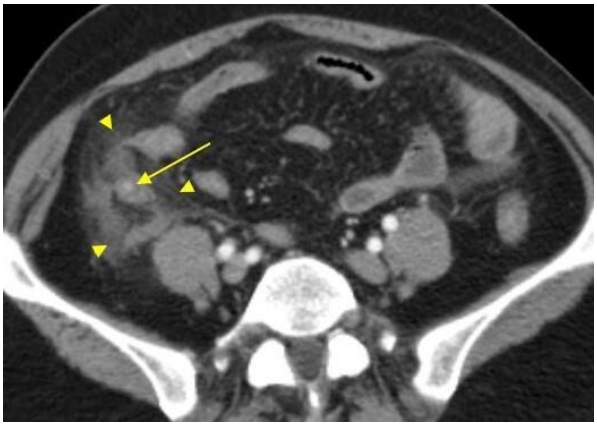

Figure 3. The axial CT image of a patient with appendix perforation; the arrow shows the appendicolith and the arrowheads show fat stranding

Results

Fifty-two (71.2%) of the patients were male and 21 (28.8%) were female. The mean age of the patients was 45.1±18.2 years with a range of 18-87. Forty (54.8%) patients had perforations of the appendix and 25 (34.2%) had gastroduodenal perforations. The demographic characteristics and perforation sites of the patients are presented in Table 1.

Table 1. Demographic characteristics and perforation sites of the patients

	n(%)
Age	45.1±18.2
Male	52 (71.2)
Female	21 (28.8)
Gastroduodenum	25 (34.2)
Small intestine	3 (4.1)
Colorectum	5 (6.9)
Appendix	40 (54.8)

n: Number of patients

Fifty-six (76.7%) patients were screened with CT, 55 (75.3%) with USG, and 48 (65.8%) with RG. The RG was primarily performed for gastroduodenal perforations, CT was primarily performed for small intestine and colorectal perforations and USG for appendix perforations. There was a significant difference in terms of the presence or absence of RG, USG, and CT examinations according to the site of perforation. The p values of these differences are $p=0.040$, $p<0.01$, and $p<0.01$, respectively (Table 2). Only one of these examinations was performed in 12 (16.4%) of the patients, while 25 (34.2%) patients underwent RG, USG, and CT examinations. The examinations performed in the patients before surgery are presented in Table 3.

Table 2. Use of radiography, ultrasonography, and computed tomography examination according to the site of perforation

Site of perforation	RG was used n(%)	USG was used n(%)	CT was used n(%)
Gastroduodenum (n=25)	20 (80.0)	17 (68.0)	23 (92.0)
Small intestine (n=3)	1 (33.3)	0 (0)	3 (100)
Colorectum (n=5)	1 (20)	0 (0)	5 (100)
Appendix (n=40)	26 (65.0)	38 (95.0)	25 (62.5)
All patients (n=73)	48 (65.8)	55 (75.3)	56 (76.7)
p value	0.040	<0.001	0.017

n: Number of patients; RG: direct radiography; USG: ultrasonography; CT: computed tomography

Table 3. Co-use and percentage distribution of examinations performed in patients

Examination	Appendix perforation n(%)	Non-appendix perforation n(%)	All n(%)
Only RG	0 (0)	1 (3.0)	1 (1.4)
Only USG	2 (5.0)	0 (0)	2 (2.7)
Only CT	1 (2.5)	8 (24.2)	9 (12.3)
RG and USG	13 (32.5)	1(3.0)	14 (19.2)
RG and CT	1 (2.5)	7 (21.2)	8 (11.0)
USG and CT	11 (27.5)	3 (9.1)	14 (19.2)
RG, USG, and CT	12 (30.0)	13 (39.4)	25 (34.2)
Total	40 (100)	33 (100)	73 (100)

RG: direct radiography; USG: ultrasonography; CT: computed tomography

The evaluation of RG images of patients for the presence of subdiaphragmatic free air showed that 50% of the patients with non-appendix perforations had subdiaphragmatic free air. None of the RG images of patients suffering from perforations of the appendix showed free air.

The most common findings in the USG images of patients suffering from appendix perforations were increased diameter and heterogeneity of mesenteric fatty tissue, while the most common finding in other perforations was free fluid.

The most common CT finding in patients suffering from perforations of the appendix was an increase in diameter (100%), while the least common finding was periappendiceal air (20%) (Table 4). In the other perforations, free air was the most common CT finding (96.8%) (Table 5).

The perforation site was correctly determined in 26 (83.9%) of the 31 patients diagnosed with non-appendix perforations who underwent CT examinations.

Discussion

In our study, at least one out of RG, USG, and CT was used for the diagnosis of patients with GIP. Among these, the least used diagnostic modality was RG. RG is a fast and inexpensive diagnostic modality and is useful in the diagnosis of GIP and for differential diagnosis. However, the site of perforation cannot be determined with RG, and its sensitivity is too low in cases in which the amount of air is small. In addition, false positive results may occur with the spread of air from other injury sites, such as the lungs, mediastinum, and

genitourinary system[12]. The incidence of free air observed in RG has been reported to be 50%-70% in the literature[4-5]. In our study, this incidence rate was 50%. A study that only evaluated patients with gastroduodenal perforations reported an incidence rate of 86%[13]. In our study, this incidence rate was also 50%. There is little or no free air involved in perforations of the appendix[14]. In our study, no free air was observed in RG images of any of the patients with appendix perforations.

Table 4. CT findings of patients with appendix perforations

CT Finding	n(%) Total n=25
Increase in diameter	25 (100)
Mucosal hyperenhancement	15 (60.0)
Mucosal defect	17 (68.0)
Periappendiceal air	5 (20.0)
Periappendiceal fluid	15 (60.0)
Moderate or advanced fat stranding	23 (92.0)
Appendicolith	10 (40.0)
Abscess	7 (28.0)

CT: Computed tomography; n: number of patients

In non-appendix perforations, signs such as pneumoperitoneum, intestinal wall thickening, increased echogenicity in mesenteric fatty tissue, and free fluid may be observed on USG. In our study, the most common USG finding was free fluid, and USG images of 13 (72.2%) of the 18 patients showed free fluid. The perforation sites of patients were not indicated in any USG images. USG does not play a major role in the diagnosis of non-appendix perforations, but it is reliable and widely used in the diagnosis of appendicitis[15]. Findings such as increased appendix diameter, periappendiceal fat inflammation, and the presence of appendicoliths can help determine whether the appendix is perforated in a patient diagnosed with appendicitis by USG[16]. The sensitivity of ultrasound imaging for appendicitis perforations in the diagnosis of appendix perforation was reported to be between 29% and 84% in the literature[17]. Since our study only included patients with perforations, this sensitivity could not be calculated.

Table 5. CT findings of patients with perforation of the gastroduodenum, small intestine, and colorectum

CT Finding	n(%) Total n=31
Mural discontinuity	14 (45.2)
Mural thickening	16 (51.6)
Free air	30 (96.8)
Free fluid	25 (80.6)
Mural contrast	15 (48.4)
Fat stranding	17 (54.8)

CT: Computed tomography; n: number of patients

The use of CT in the diagnosis of perforations has increased significantly in recent years due to its diagnostic accuracy[18]. In our study, 93.9% of the patients with non-appendix perforations underwent CT examinations. CT was the most commonly performed examination in these patients. CT is the most reliable imaging method for determining the presence of GIP and its site, cause, and complications. One of the most important findings used to determine the site of perforations by CT is mural discontinuity. This finding can directly indicate the site of the perforation, but its incidence rate is low. In the study by Imuta et al.[19], the perforation site of 52% of their patients was directly imaged with mural discontinuity. The rate of this occurrence was 45.2% in our study. The site of perforation can be determined by CT using all CT findings with 80%-95% success [3,9,10,20,21]. In our study, the site of perforation was accurately determined in 83.9% of patients. We did not include appendix perforations in our study when determining the site of perforation because

appendix perforation is a complication of appendicitis and it is easy to recognize appendicitis with CT. However, there is no single specific CT finding to distinguish between perforated appendicitis and non-perforated appendicitis[22]. For this reason, the role of scoring systems using CT findings is being investigated[23]. In our study, we evaluated CT findings that may be useful in the differential diagnosis of perforated appendicitis. An increase in diameter (100%) and periappendiceal moderate or advanced fat stranding (92%) were the most common findings.

Magnetic resonance imaging (MRI) may be applied in children and pregnant women since it does not utilize radiation. Rapid diagnosis can be achieved in acute intestinal pathologies with high-speed sequences[5]. In our study, MRI was not performed in any patient.

Limitations of the Study: This study was retrospective and the number of patients was low.

Conclusion

RG, USG, and CT examinations were used in the diagnosis of GIP. Of these, CT was the method used most and it had the highest diagnostic value. CT was also useful in determining the site of perforation. Using CT findings, we determined the perforation site with a success rate of 83.9%.

Author contributions

All authors contributed to the study conception and design. All authors read and approved the final manuscript.

Conflict of interest

The authors declare that they have no conflict of interest.

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Ethical approval

This retrospective study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Malatya Turgut Özal University Clinic Ethics Committee (Date: 2022, Decision no: 95).

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