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RESEARCH

Effectiveness of X-ray film in diagnosing peptic ulcer perforation

Peptik ülser perforasyonu tanısını koymada X-ray filminin etkinliği

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Abstract

Purpose: A retrospective case-control study was undertaken to assess the diagnostic efficacy of X-ray film in detecting peptic ulcer perforation (PUP).

Materials and Methods: The study retrieved demographic data, perioperative observations, and postoperative results of 353 patients from the hospital repository. These individuals were categorized into two cohorts depending on the detection of intraperitoneal free air on X-ray imaging.

Results: The study cohort exhibited a median age of 57 years (interquartile range: IQR 38-71), comprising predominantly males (82.4%). Intraperitoneal free air was evident in 73.1% of patients on X-ray imaging. In the multivariate analyses of the respective groups, time interval and diabetes mellitus (DM) emerged as independent risk factors. Notably, the sensitivity of X-ray film heightened with prolonged duration between symptom onset and emergency department admission, while specificity increased in the presence of DM.

Conclusion: The imperative for supplementary imaging modalities in conjunction with clinical assessment is apparent in the diagnostic approach to PUP. Nonetheless, the fluctuation in sensitivity and specificity of X-ray film concerning DM and the duration from symptom onset to emergency department admission warrants careful consideration. Especially in cases where clinical suspicion of PUP exists despite the absence of intraperitoneal free air on X-ray, the utilization of advanced diagnostic techniques is advocated.

Keywords:. Perforated peptic ulcer, X-Ray film, efficiency

Öz

Amaç: Peptik ülser perforasyonu (PUP) tanısında X-Ray filminin etkinliğini araştırmak amacıyla retrospektif bir vaka-kontrol çalışması tasarlandı.

Gereç ve Yöntem: Çalışmaya dahil edilen 353 hastanın demografik verileri, perioperatif bulguları ve postoperatif bulgularına hastane veritabanından ulaşıldı. X-Ray filminde intraperitoneal serbest hava durumuna göre iki grup oluşturuldu.

Bulgular: Popülasyonunun median yaşı 57'idi (IQR 38-71) ve hastaların %82.4'ü erkekti. X- Ray filminde hastaların %73.1'inde intraperitoneal serbest hava gözlemlendi. Gruplar arasında, multivariate analizlerde yalnızca zaman ve diabetes mellitus (DM) bağımsız risk faktörlerleriydi. Semptomların başlangıcı ile acil servise başvurunun arasındaki süre uzadıkça X-ray filminin duyarlılığının arttığı, DM'nin varlığında özgüllüğünün arttığı gözlemlendi.

Sonuç: PUP tanısında klinik değerlendirmeye ek olarak yardımcı görüntüleme yöntemlerinin gerekliliği açıktır. Ancak, X-Ray filminin hassasiyet ve özgüllüğündeki DM'ye bağlı değişkenlik ve semptom başlangıcından acil servise başvuruya kadar geçen süre dikkate alınmalıdır. Özellikle intraperitoneal serbest hava olmaksızın PUP şüphesi bulunan hastalarda, ileri tanısal yöntemlerin kullanımı önerilir.

Anahtar kelimeler: Peptik ülser perforasyonu, X ışını Filmi, etkinlik

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INTRODUCTION

Peptic ulcers, resulting from an imbalance in the acid-mucosal defense mechanism across the gastrointestinal tract, manifest as mucosal erosions. Predominantly observed in the gastric antrum and duodenum, duodenal ulcers stem from hyperacidity, while gastric ulcers arise from mucosal defense compromise. With a lifetime prevalence of 10%, traditional etiological factors such as stress and cigarette smoking have been supplemented by the rising incidence of H. pylori infection and non-steroidal anti-inflammatory drug (NSAID) usage, altering the epidemiological landscape[1]. Perforation, characterized by the ulcer penetrating all anatomical layers, stands as the second most frequent complication of peptic ulcers, with occurrence rates ranging from 0.004% to 0.014%. Remarkably, perforation accounts for two-fifths of ulcer-related mortalities[2,3].

Among patients afflicted with PUP, the primary symptom typically manifests as an acute and intense epigastric pain, which may extend owing to peritonitis induced by acid exposure. Notably, approximately two-thirds of patients exhibit evident signs of peritonitis upon presentation[4].

Standard laboratory assays lack diagnostic specificity for PUP and primarily serve in the realm of differential diagnosis. The diagnostic emphasis lies predominantly on physical examination and radiological imaging modalities.

In the upright or seated position, direct X-ray imaging may reveal characteristic signs of perforation, including the double-wall appearance of the intestines, a well-defined liver edge, and subdiaphragmatic free air. However, pneumoperitoneum may be absent in 30% of cases[5]. In instances where closed perforation is suspected and diagnostic uncertainty persists despite the absence of pneumoperitoneum on X-ray, Computer Tomography (CT) emerges as a preferred imaging modality due to its heightened diagnostic accuracy[6]. While ultrasound can detect peritoneal free air, its utility lies more in confirming the diagnosis through indirect findings such as intestinal immobility and intraperitoneal free fluid, suggestive of perforation[7].

The variability in sensitivity and specificity of X-ray films for diagnosing peptic ulcer perforation underscores the need for further investigation. This study sought to evaluate the efficacy of X-ray films in identifying peptic ulcer perforation, correlating findings with clinical-pathological and operative data.

MATERIALS AND METHODS

Sample and study design

Data from a cohort of 362 patients who underwent operative intervention for suspected luminal organ perforation between 2002 and 2022 were extracted from the hospital database. Exclusion criteria eliminated nine patients lacking peptic ulcer perforation upon operative exploration, comprising two cases of small bowel perforation due to blunt trauma, four cases of sigmoid colon diverticulum perforation, and three cases of perforation associated with rectosigmoid colon tumors.

Demographic characteristics (age, gender, comorbidities [such as diabetes mellitus, malignancy]), clinical parameters (time of admission to the emergency department [hours], mean arterial blood pressure [mmHg], pulse rate [beats per minute], mortality, morbidity), and laboratory values (White blood cell count [10^3/uL], blood urea nitrogen [mg/dL], creatinine [mg/dL]) were documented. Perforation site (gastric or duodenal) and perforation size (centimeters) were delineated based on operative findings. Postoperative complications were stratified according to the Clavien-Dindo (CD) classification, distinguishing between mild (grades 1-2) and severe (grades 3-4) complications. Subsequently, two cohorts were delineated based on the presence or absence of subdiaphragmatic air on direct X-ray imaging, and between-group disparities were scrutinized.

Inclusion criteria

1. Patients who underwent surgery due to acute abdomen, regardless of the presence or absence of free air below the diaphragm.
2. Patients aged 18 and above.

Exclusion criteria:

1. Excluding luminal organ perforations other than peptic ulcer perforation.

This study received approval from the Inönü University Scientific research and publication ethics board, with a waiver of informed consent (Date: 14/11/2023, Number: 2023/5114).

Procedure

Subsequent to induction of general anesthesia, abdominal exploration ensues via a midline incision positioned above the umbilicus. Purulent and bile-stained fluid is lavaged with normal saline solution and subsequently aspirated. Identification of the perforation site within the stomach or duodenum prompts the preparation of an omental flap, which is meticulously positioned and secured using 2.0 or 3.0 round needle silk sutures, tailored to tissue resilience (Graham procedure).

Optionally, the falciform ligament may be released to fashion a plug at the perforation site (Falciformopexy). Antrectomy may be considered at the surgeon's discretion in cases where the defect exceeds 2 cm, recurrent peptic ulcer perforation is evident, or if the patient necessitates antiplatelet therapy. Following antrectomy, either a Billroth I or Billroth II gastrojejunostomy is performed as dictated by clinical exigencies

Definition

Postoperative complications among patients were systematically classified according to the CD classification system by two experienced senior surgeons. Complications amenable to resolution with straightforward medical interventions were designated as CD grades 1 and 2, indicative of mild severity. Conversely, instances necessitating interventional procedures, surgical interventions, or leading to single/multi-organ failure were allocated to CD grades 3 and 4, reflecting severe complications[8].

Statistical analysis

The sample size for this study was determined using power analysis with G-Power 3.1 software. A power (1-β) of 0.90 and a confidence level of 95% were considered, resulting in a calculated sample size of 90 participants per group. Therefore, a minimum total sample size of 180 participants was determined for both groups. The statistical analyses were performed using SPSS v23.

The normality of the distribution was assessed using the Kolmogrov Smirnov test. Descriptive statistics, including median and interquartile range (IQR), were reported for the variables. Quantitative data in independent groups that did not follow a normal distribution were analyzed using the Mann-Whitney U test. Categorical variables were analyzed using chi-square analysis, and the results were presented as frequencies and percentages.

For the development of the regression model, all variables were initially included, and the backward stepwise Wald method was utilized to iteratively select the most significant predictors and refine the model. This meticulous approach enabled us to attain the final, best-performing model. The assumption of multicollinearity was evaluated for the final model. The goodness of fit was assessed using the Hosmer & Lemeshow test. The overall performance of our model was evaluated using the Nagelkerke R Square. Statistical significance was defined as $p < 0.05$.

RESULTS

In our study population consisting of 353 patients, the median age (IQR) was 57 (38-71), and 291 (82.4%) were male. Among the patients, 68 (19.3%) had DM, and 18 (5.1%) had concomitant malignancy. The median time elapsed between the onset of symptoms and presentation to the emergency department was 24 (8-36) hours. Erect abdominal and chest films revealed intraabdominal free air in 258 (73.1%) patients. The majority of operated patients underwent open surgery, with 83.9% of them undergoing Graham repair (Table 1). In the conducted analyses between the created groups, there were statistically significant differences in the presence of diabetes mellitus (p=0.005), the time elapsed between the onset of symptoms and presentation to the emergency department (p<0.001) (Figure 1), defect size (p=0.022), and blood urea nitrogen (BUN) levels (p=0.009) (Table 2).

There were no statistically significant differences observed between the groups in terms of age, gender, concomitant malignancy, pulse rate, mean arterial pressure, white blood cell count (WBC), creatinine levels, and perforation localization (Table 3).

In the multivariate regression analysis, it was observed that DM (OR: 2.758, CI: 1.256-6.059, p=0.011) and time to admission (OR: 3.579, CI: 2.117-6.052, p<0.001) were independent risk factors (Table 3). The sensitivity of X-Ray film in detecting intraperitoneal free air is 74.03% when the time elapsed between symptom onset and presentation to the emergency department is >12 hours. In patients with DM, the specificity is 90.53% (Table 4) (Figure 2).

Table 1. Demographic and operative data of patients

Variables		Median (IQR)	Count(%)
Age, years		57(38-71)	
Gender	Male		291(82.4%)
	Female		62(17.6%)
DM	Absence		285(80.7%)
	Presence		68(19.3%)
Malignancy	Absence		335(94.9%)
	Presence		18(5.1%)
Time of admission to the ED (h)		24(8-36)	
Time of admission to the ED	<12hour		121(34.3%)
	>12hour		232(65.7%)
IFA on X-Ray film	Absence		95(26.9%)
	Presence		258(73.1%)
Operation Type	Graham		296(83.9%)
	Falciformepexy		48(13.6%)
	Antrectomy		9(2.5%)
Minimal Invaziv Surgery	Absence		345(97.7%)
	Presence		8(2.3%)

IQR: Interquartile range, DM: Diabetes mellitus, IFA: Intraperitoneal free air, ED: Emergency department

Table 2. Analysis of groups determined according to Intraperitoneal free air status in X-Ray film

Variables		Absence IFA on X-ray film		Presence IFA on X-ray film		P- Value
		Median(IQR)	Count(%)	Median(IQR)	Count(%)	
Age, years		54(35-72)		59(40-71)		0.316*
Gender	Male		78(82.1%)		213(82.6%)	
	Female		17(17.9%)		45(17.4%)	0.921
DM	Absence		86(90.5%)		199(77.1%)	
	Presence		9(9.5%)		59(22.9%)	0.005
Malignancy	Absence		88(92.6%)		247(95.7%)	
	Presence		7(7.4%)		11(4.3%)	0.240
Time of admission to the ED (h)		10(5-24)		24(12-48)		<0.001*
Time Categoric	<12hour		54(56.8%)		67(26%)	
	>12hour		41(43.2%)		191(74%)	<0.001
Defect Location	Stomach		29(30.5%)		70(27.1%)	
	Duodenum		66(69.5%)		188(72.9%)	0.529
Defect Size (cm)		0.5(0.5-1)		0.5(0.5-1)		0.022*
Heart Rate(n)		88(75-100)		90(78-104)		0.244*
BP(mmHg)		92.6(86.6-100)		92.3(83.6-100)		0.737*
WBC, 10^3/uL		12.6(9.2-19)		13.8(8.5-17.9)		0.910*
Creatinine, mg/dL		1(0.79-1.40)		1(0.85-1.5)		0.233*
BUN, mg/dL		20.8(14-33)		25.5(18-38)		0.009*
CD	1-2		78(82.1%)		182(70.5%)	
	3-4		17(17.9%)		76(29.5%)	0.029
Mortality			9(9.5%)		31(12%)	0.504

IFA: Intraperitoneal free air, IQR: Interquartile range, DM: Diabetes mellitus, ED: Emergency department, BP: Blood pressure, WBC: white blood cell, BUN: blood urea nitrogen, CD: Clavien Dindo classification. * Mann-Whitney U test results were considered significant at $p<.05$

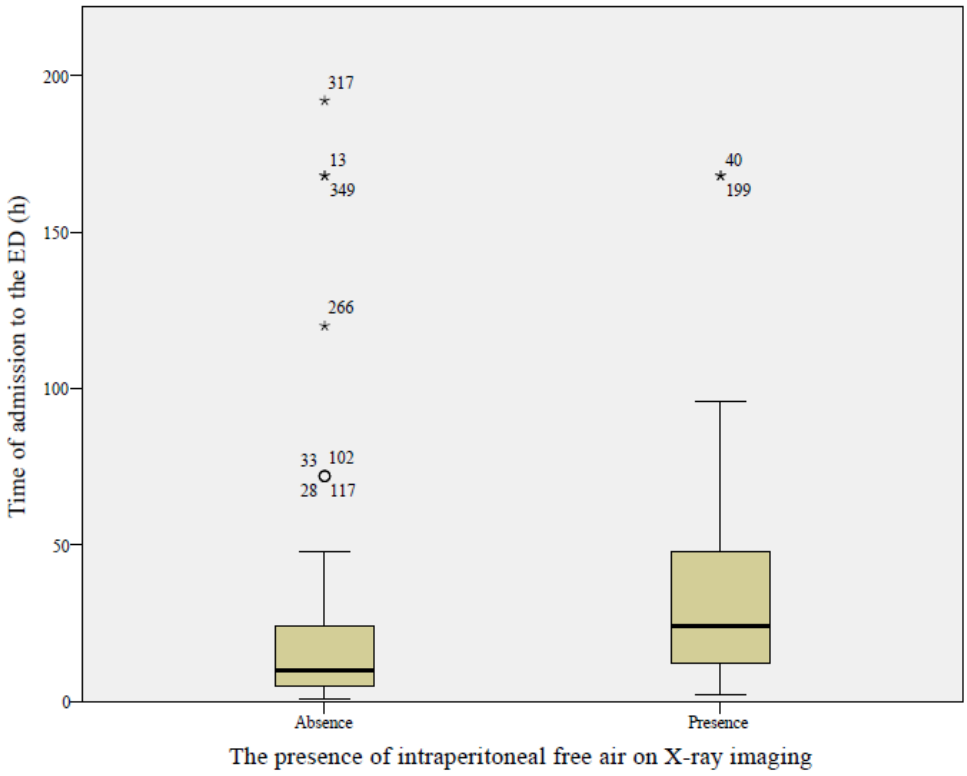

Figure 1. The graphical representation of the time elapsed between the onset of symptoms and the presentation to the emergency department (ED) for the presence or absence of intraperitoneal free air on X-Ray film.

Table 3. Multivariate logistic regression analysis results.

	Multivariate Logistic Regression		
Variables	**OR**	**95.0% CI**	**P-Value**
12 h< Time of admission to the ED	3.579	2.117-6.052	**< 0.001**
Defect Size (cm)	1.258	0.779-2.030	0.347
BUN	0.717	0.983-1.012	0.717
DM	2.758	1.256-6.059	**0.011**

DM: Diabetes mellitus, ED: Emergency department, BUN: blood urea nitrogen, OR: Odds ratio CI: Confidence interval. p<.05 was considered statistically significant.

Table 4. Effectiveness of intraperitoneal free air detection in X-Ray film with different variables

Variables	**Sensitivity**	**Specificity**	**PPV**	**NPV**
DM	29.65%	90.53%	86.77%	36.60%
12 h< Time of admission to the ED	74.03%	56.84%	82.33%	44.63%

DM: Diabetes mellitus, ED: Emergency department, PPV: Positive Predictive Value; NPV: Negative Predictive Value

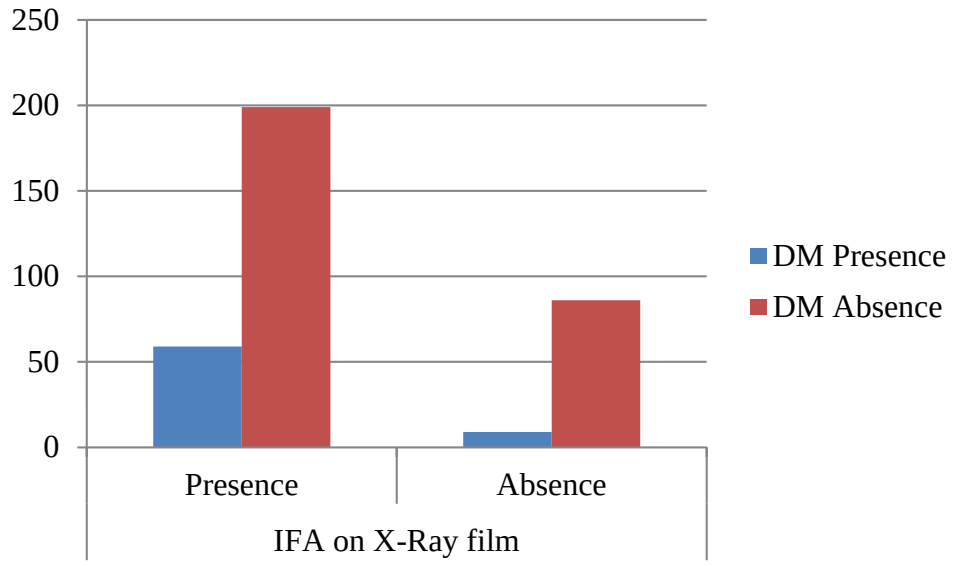

Figure 2. Detection of intraperitoneal free air (IFA) status on X-Ray film in patients with diabetes mellitus (DM).

DISCUSSION

Presently, aided by algorithms, the diagnosis and management of PUP have become more streamlined[4]. While patient history and clinical presentation remain pivotal in diagnosis, imaging modalities also play a significant role. Erect X-ray imaging, although not notably sensitive, holds variable utility contingent upon several factors. In our investigation, only 73.1% of patients undergoing surgical intervention for PUP exhibited intraperitoneal free air on X-ray imaging. Time of symptom onset and the presence of DM emerged as independent determinants for detecting intraperitoneal free air on X-ray imaging. Furthermore, diagnostic sensitivity of X-ray imaging escalated with each hour of delayed presentation to the emergency department, while specificity was augmented in the presence of DM.

Across diverse studies, the reliability of diagnostic methodologies for PUP has been extensively validated. Notably, erect X-ray film is recognized for its relatively low sensitivity in diagnosis. Furthermore, investigations have elucidated that the size and anatomical localization of the perforation can influence the test's sensitivity. Specifically, findings indicate a notable increase in sensitivity in cases localized to the duodenum ($p < 0.05$) and presenting with a larger size ($p < 0.01$)[9]. However, our study findings diverge, suggesting that the anatomical localization of the perforation does not significantly impact the diagnostic efficacy of X-ray imaging. Moreover, while perforation size demonstrated significance in univariate analyses, it did not maintain effectiveness in multivariate analyses.

While scoring systems[10,11] have underscored the mortality implications of delayed presentation in PUP, our investigation additionally unveiled a decrement in the diagnostic reliability of X-ray film, particularly evident in cases presenting within <12 hours. Furthermore, our findings illuminated a higher incidence and severity of postoperative complications in the cohort exhibiting intraperitoneal free air on X-ray imaging, potentially influenced by the duration elapsed. Notably, as our institution functions as a tertiary care facility with robust intensive care capabilities, no discernible disparities in mortality rates associated with these grave complications were observed between the cohorts.

Patients with DM may experience delayed presentations to the emergency department attributed to impaired inflammatory responses and neuropathic complications. Consequently, prolonged elapsed time enhances the probability of intraperitoneal air detection. Furthermore, in instances of compromised inflammatory processes,

X-ray film specificity is augmented, impeding the localization of the perforation site. Our study findings revealed a notable increase in X-ray film specificity among patients with DM.

WBC, BUN, creatinine, and amylase levels are parameters that may elevate in PUP due to secondary factors, albeit lacking specificity for the disease[12-14]. Elevated WBC counts typically accompany inflammatory processes and can further increase in response to peritonitis and dehydration over time. Similarly, delayed presentation may result in heightened creatinine and BUN levels attributable to prerenal kidney dysfunction via similar mechanisms. Our study findings indicated an increase in the sensitivity of X-ray film with time; however, no discernible correlation was noted between prolonged duration, exacerbated dehydration secondary to peritonitis, and alterations in these laboratory parameters concerning the detection of intraperitoneal free air on X-ray imaging.

A notable limitation of our study is its retrospective nature, which precludes the comprehensive inclusion of pertinent perioperative findings such as the localization of the defect with omental involvement. Had the study been prospectively designed to encompass these variables, more robust and clinically relevant outcomes could have been derived. Addressing these limitations would significantly augment the study's utility, thereby facilitating clinicians in the diagnosis of this disease, which is known for its marked responsiveness to treatment, particularly through the cost-effective and readily accessible modality of X-ray imaging. Furthermore, such enhancements would furnish clinicians with valuable insights into the circumstances under which this diagnostic approach may be suboptimal or advantageous.

In patients presenting with acute abdominal symptoms suggestive of PUP in the emergency department, it is imperative to acknowledge that the sensitivity of X-ray imaging can be influenced by variables such as elapsed time and the presence of DM. A critical consideration arises in the subset of patients where X-ray imaging fails to detect intraperitoneal free air, resulting in an inconclusive diagnosis. In scenarios where clinical suspicion for PUP persists, particularly in cases involving DM and symptom duration less than 12 hours, it is prudent to pursue more sensitive diagnostic modalities.

In conclusion, the diagnostic efficacy of X-ray imaging for peptic ulcer perforation (PUP) exhibits variability contingent upon the presented factors. Nonetheless, future investigations guided by established protocols will facilitate the formulation of patient-specific algorithms, thereby enhancing the diagnostic approach to this condition.

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