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ORIGINAL RESEARCHES

ORIGINAL RESEARCH

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Review of Patients who had Undergone Magnetic Resonance Cholangiopancreatography Imaging in the Emergency Department

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Abstract

Objective: Magnetic resonance cholangiopancreatography (MRCP) enables a non-invasive evaluation of the anatomy and pathology of the pancreaticobiliary system rapidly, reliably, and without complications without using contrast agents. This research aimed to elucidate the routine use of MRCP imaging in emergency departments (EDs) and help patients receive more precise and rapid diagnoses in shorter periods.

Materials and Methods: This retrospective cross-sectional study included 368 patients who applied to the ED and underwent MRCP. An expert radiologist with at least 5 years of experience evaluated MRCP imaging. The images were examined based on choledocholithiasis, gallstone, bile sludge, biliary duct dilatation and cholecystitis, gallbladder perforation, acute pancreatitis, and tumor. The demographic characteristics of the patients, imaging indications, and bilirubin values were analyzed.

Results: MRCP examination revealed cholecystitis in 53.0% (n=195) of the patients, gallbladder perforation in 1.4% (n=5), acute pancreatitis in 22.0% (n=81), and gallbladder or goatskin tumor in 11.4% (n=42). None of these pathologies was found in 32.6% (n=120). Regarding gender, MRCP findings, imaging method and indications, and bilirubin grades based on four MRCP diagnoses, cholecystitis was detected in 57.8% of patients with choledocholithiasis, while the tumor was detected in only 5.8% (p=0.004). Most patients with gallstone were diagnosed with cholecystitis (70.9%), while cancer was diagnosed in only 8.5% of patients (p<0.001 and p=0.036, respectively). Biliary duct dilatation was the most common finding in patients with tumors. There was no significant difference between MRCP findings, diagnoses, and bilirubin grades in all three imaging options. Tumoral formations were detected more in patients with high bilirubin levels, while acute pancreatitis was more in patients with low bilirubin levels (p<0.05).

Conclusion: MRCP is a non-invasive , ionizing, radiation-free, complication-free, contrast-free, and premedication-free examination method with as high an accuracy rate as endoscopic retrograde cholangiopancreatography in pancreaticobiliary diseases.

Keywords: Magnetic resonance cholangiopancreatography (MRCP), pancreaticobiliary disease, cholecystitis, tumors

Introduction

Bile duct pathologies are a significant group of diseases affecting a considerable population worldwide. Bile duct stones can result in choledocholithiasis, and late diagnosis can lead to cholangitis and pancreatitis. Transabdominal ultrasound (USG) is the first-line imaging modality for evaluating biliary colic and right upper quadrant pain due to its wide availability and high sensitivity in detecting gallstones [1]. However, the ability to detect common bile duct stones with USG is limited, with sensitivity ranging from 22-55%. Other tests with better diagnostic accuracy for evaluating choledocholithiasis include endoscopic USG and endoscopic retrograde cholangiopancreatography (ERCP), both of which have sensitivities ranging from 93-97% and specificities ranging from 77-96%; however, their use in

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practice is low because they are invasive procedures, require sedation, and cannot be performed in every center [1,2].

Computed tomography (CT) is a non-invasive imaging technique widely used to diagnose and monitor most pancreatic and biliary system diseases. It complements magnetic resonance cholangiopancreatography (MRCP) in imaging biliary tract diseases. CT and magnetic resonance (MR) can also provide information about the extra biliary spread of gallbladder and bile duct diseases that cannot be obtained with USG. MRCP is a non-invasive alternative imaging method with a diagnostic profile comparable to endoscopic ultrasound and ERCP, having a sensitivity ranging from 85-92% and a specificity of 93-97% [3]. The American Society of Gastrointestinal Endoscopy recommends MRCP in cases of symptomatic cholelithiasis [4].

MRCP is now the preferred imaging modality for diagnosing biliary obstruction. When performed in the emergency department (ED), the procedure can help identify the underlying cause of obstruction, and expedite triage for patients needing ERCP. MRCP can shorten the length of stay in the ED and enable patients to reach the correct diagnosis more quickly [5].

Because USG is operator-dependent and CT involves radiation exposure, MRCP is considered the gold standard for diagnosing biliary tract pathologies with high accuracy [6]. Within the scope of this research, we aimed to elucidate the routine use of MRCP imaging in EDs and help patients receive more precise and rapid diagnoses in EDs.

Materials and Methods

This retrospective cross-sectional study included 368 patients who presented to the ED of Giresun Training and Research Hospital between 01.01.2020 and 31.12.2022 and underwent MRCP. All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. Ethics committee approval has been granted by the Clinical Research and Ethics Committee of Giresun Training and Research Hospital (approval number: 02, date: 27.02.2023). An expert radiologist with at least 5 years of experience evaluated MRCP imaging. The images were examined based on four findings (choledocholithiasis, gallstone, bile sludge, and biliary duct dilatation) and four diagnoses [cholecystitis, gallbladder perforation, acute pancreatitis, and tumor (gallbladder or klatskin)]. The demographic characteristics of the patients (age, gender), imaging indications, and bilirubin values (both numerical and group) were noted.

Inclusion Criteria

- Having presented to the ED
- Being over 18 years of age
- Having MRCP imaging performed within medical necessity

Exclusion Criteria

- Having MRCP performed after 24 hours of applying to the ED
- Patients whose request was ED without applying to the ED due to technical difficulties
- Patients whose MRCP images could not be accessed for any reason

Standardized Magnetic Resonance Cholangiopancreatography Protocol in the Emergency Department

- MRCP was ordered based on predefined clinical criteria, including:
- Persistently elevated bilirubin levels (>2 mg/dL)
- Biliary colic with inconclusive USG findings
- Suspected choledocholithiasis not confirmed by USG
- Pancreatitis of unclear etiology

Statistical Analysis

Patient data collected within the scope of the study were analyzed with the IBM Statistical Package for the Social Sciences (SPSS) for Windows 26.0 (IBM Corp., Armonk, NY). Frequencies and percentages for categorical data, and means and 95% confidence intervals (CI) for continuous data, were provided as descriptive values. For comparisons between groups, the "independent sample t-test" was used for two groups, and the "Pearson chi-square test" was used to compare categorical variables. The results were considered statistically significant when the p-value was less than 0.05.

Results

A total of 368 patients, 167 (45.4%) of whom were women, were included in the study. The mean age of women was 70.1±18.3, and the mean age of men was 69.1±15.2, with a total mean age of 69.7±17.0. As a result of MRCP examination, cholecystitis was detected in 53.0% (n=195) of the patients, gallbladder perforation in 1.4% (n=5), acute pancreatitis in 22.0% (n=81), and gallbladder or Klatskin tumor in 11.4% (n=42). None of these pathologies was found in 32.6% (n=120).

Table 1 denotes the imaging methods, gender, MRCP findings, and diagnoses, imaging indications, and bilirubin levels. Patients who underwent MRCP without USG, or CT, those who underwent CT before, and those who underwent both USG and CT before, were compared separately. There was no significant difference among MRCP findings, diagnoses, and bilirubin grades in all three imaging options.

Table 2 shows gender, MRCP findings, imaging method and indications, and bilirubin grades, based on four MRCP diagnoses. Cholecystitis was detected in 57.8% of patients with

choledocholithiasis, while tumor was detected in only 5.8% (p=0.004). Most patients with gallstone were diagnosed with cholecystitis (70.9%), while cancer was diagnosed in only 8.5% of patients (p<0.001 and p=0.036, respectively). Biliary duct dilatation was the most common finding in patients with tumors.

Table 3 compares MRCP diagnoses with age and bilirubin (total and direct) levels. Tumoral formations were more commonly detected in patients with high bilirubin levels, while acute pancreatitis was more common in patients with low bilirubin levels (p<0.05).

Table 4 indicates patients not diagnosed with the four primary diagnoses as investigated using MRCP. While at least one pathology was detected in most patients with gallstones, no clear association could be found between bilirubin levels and the absence of pathologies.

Univariate and multivariate logistic regression analyses were performed to evaluate the relationship between demographic factors and laboratory values and pathology detection in MRCP (Table 5). In both models, age was significantly associated with pathology detection [odds ratio (OR): 1.016, 95% CI: 1.003-1.029, p=0.017]

Table 1. Comparison of imaging methods performed before MRCP examination with gender, MRCP findings and diagnoses, imaging indication and bilirubin grades

		No imaging (USG or CT)	p-value	CT	p-value	Both USG and CT	p-value
Gender	Female	16 (8.0)	0.725	166 (82.6)	0.316	31 (15.4)	0.341
	Male	15 (9.0)		131 (78.4)		20 (12.0)	
Choledocholithiasis	No	14 (6.5)	0.125	170 (79.4)	0.468	34 (15.9)	0.184
	Yes	17 (11.0)		127 (82.5)		17 (11.0)	
Gallstone	No	16 (10.3)	0.263	123 (79.4)	0.575	22 (14.2)	0.874
	Yes	15 (7.0)		174 (81.7)		29 (13.6)	
Bile sludge	No	28 (11.5)	**0.003**	194 (79.5)	0.414	28 (11.5)	0.063
	Yes	3 (2.4)		103 (83.1)		23 (18.5)	
Biliary duct dilatation	No	8 (6.1)	0.222	105 (79.5)	0.677	24 (18.2)	0.073
	Yes	23 (9.7)		192 (81.4)		27 (11.4)	
Imaging indication	Biliary duct dilatation	47 (28.7)	0.286	143 (87.2)	0.586	22 (13.4)	0.842
	Choledochus stone	2 (40.0)		5 (100)		0 (0.0)	
	Gallstone	19 (33.9)		47 (83.9)		12 (21.4)	
	Mass	4 (23.5)		15 (88.2)		2 (11.8)	
	Other	39 (41.1)		87 (91.6)		15 (15.8)	
Bilirubin grade	<1 mg/dL	6 (9.4)	0.188	51 (79.7)	0.404	5 (7.8)	0.371
	1-2 mg/dL	6 (8.1)		61 (82.4)		9 (12.2)	
	2-5 mg/dL	10 (7.0)		117 (82.4)		24 (16.9)	
	5-10 mg/dL	4 (6.2)		53 (81.5)		11 (16.9)	
	>10 mg/dL	5 (21.7)		15 (65.2)		2 (8.7)	
Bilurubin. total <2 mg/dL	<2 mg/dL	12 (8.6)	0.910	113 (81.3)	0.824	14 (10.1)	0.101
	>2 mg/dL	19 (8.3)		184 (80.3)		37 (16.2)	
Bilurubin. total <5 mg/dL	<5 mg/dL	22 (7.8)	0.460	230 (81.9)	0.318	38 (13.5)	0.738
	>5 mg/dL	9 (10.3)		67 (77.0)		13 (14.9)	
Cholecystitis	No	16 (9.2)	0.592	139 (80.3)	0.869	21 (12.1)	0.368
	Yes	15 (7.7)		158 (81.0)		30 (15.4)	
Gallbladder perforation	No	31 (8.5)	0.495	293 (80.7)	0.968	51 (14.0)	0.367
	Yes	0 (0.0)		4 (80.0)		0 (0.0)	
Acute pancreatitis	No	21 (7.3)	0.150	233 (81.2)	0.662	45 (15.7)	0.057
	Yes	10 (12.3)		64 (79.0)		6 (7.4)	
Tumor (glallbladder or klatskin)	No	29 (8.9)	0.364	260 (79.8)	0.197	47 (14.4)	0.388
	Yes	2 (4.8)		37 (88.1)		4 (9.5)	

MRCP: Magnetic resonance cholangiopancreatography, CT: Computed tomography, USG: Ultrasound

Discussion

Unlike CT and X-ray, which involve ionizing radiation with potential long-term risks, magnetic resonance imaging (MRI) offers superior contrast resolution and tissue differentiation. Thus, it is widely preferred for imaging various structures, including the brain, spinal cord, bone marrow, musculoskeletal system, cardiovascular system, and abdominal and pelvic organs. It is the method that reveals the relationship between anatomical structures in the optimal way [7]. MRCP is a non-invasive method that can be preferred in the diagnosis of bile duct pathologies due to its features, including lack of ionizing radiation, absence of complication risk, no requirement for patient preparation, applicability during pancreatitis and cholangitis attacks, and the ability to obtain images in different planes [8]. With this method, the anatomy and pathology of the bile and pancreatic ducts are evaluated rapidly, reliably, and without complications, using no contrast agents [9]. MRCP shows stationary fluids such as bile and pancreatic fluid with higher signal intensity than the surrounding soft tissues. Only stagnant or slowly moving fluids within anatomical structures

Table 2. Comparison of MRCP diagnoses with gender, MRCP findings, imaging methods and bilirubin grades

	Cholecystitis		Acute pancreatitis		Tumor (gallbladder or klatskin)		Gallbladder perforation	
	n (%)	p-value	n (%)	p-value	n (%)	p-value	n (%)	p-value
Gender								
Female	111 (55.2)	0.346	44 (21.9)	0.951	23 (11.4)	0.984	2 (1.0)	0.509
Male	84 (50.3)		37 (22.2)		19 (11.4)		3 (1.8)	
Choledocholithiasis	89 (57.8)	0.117	32 (20.8)	0.629	9 (5.8)	**0.004**	2 (1.3)	0.933
Gallstone	151 (70.9)	**<0.001**	52 (24.4)	0.192	18 (8.5)	**0.036**	3 (1.4)	0.923
Bile sludge	81 (65.3)	**0.001**	17 (13.7)	**0.006**	15 (12.1)	0.769	1 (0.8)	0.514
Biliary duct dilatation	131 (55.5)	0.195	48 (20.3)	0.301	38 (16.1)	**<0.001**	3 (1.3)	0.846
Ultrasound	52 (57.1)	0.360	13 (14.3)	**0.040**	7 (7.7)	0.198	1 (1.1)	0.805
CT	158 (53.2)	0.869	64 (21.5)	0.662	37 (12.5)	0.197	4 (1.3)	0.968
Imaging								
No imaging	15 (48.4)	0.608	10 (32.3)	0.078	2 (6.5)	0.409	0 (0.0)	0.484
USG or CT	150 (52.4)		65 (22.7)		36 (12.6)		5 (1.7)	
USG and CT	30 (58.8)		6 (11.8)		4 (7.8)		0 (0.0)	
Imaging indication								
Biliary duct dilatation	93 (56.7)	0.075	30 (18.3)	0.110	27 (16.5)	**<0.001**	1 (0.6)	0.550
Choledochus stone	3 (60.0)		2 (40.0)		0 (0.0)		0 (0.0)	
Gallstone	36 (64.3)		8 (14.3)		2 (3.6)		1 (1.8)	
Mass	7 (41.2)		3 (17.6)		6 (35.3)		0 (0.0)	
Other	41 (43.2)		28 (29.5)		5 (5.3)		3 (3.2)	
Bilirubin grade								
<1 mg/dL	27 (42.2)	**0.003**	19 (29.7)	0.065	4 (6.3)	**<0.001**	1 (1.6)	0.772
1-2 mg/dL	50 (67.6)		22 (29.7)		7 (9.5)		2 (2.7)	
2-5 mg/dL	75 (52.8)		27 (19.0)		9 (6.3)		1 (0.7)	
5-10 mg/dL	37 (56.9)		11 (16.9)		13 (20.0)		1 (1.5)	
>10 mg/dL	6 (26.1)		2 (8.7)		9 (39.1)		0 (0.0)	
Bilirubin total <2 mg/dL								
<2 mg/dL	78 (56.1)	0.349	41 (29.5)	**0.007**	11 (7.9)	0.100	3 (2.2)	0.302
>2 mg/dL	117 (51.1)		40 (17.5)		31 (13.5)		2 (0.9)	
Bilirubin total <5 mg/dL								
<5 mg/dL	152 (54.1)	0.466	68 (24.2)	0.069	20 (7.1)	**<0.001**	4 (1.4)	0.847
>5 mg/dL	43 (49.4)		13 (14.9)		22 (25.3)		1 (1.1)	

MRCP: Magnetic resonance cholangiopancreatography, CT: Computed tomography, USG: Ultrasound

can be seen [10]. Although ERCP is still the standard reference for evaluating bile and pancreatic ducts, MRCP is used for diagnostic purposes in many centers [11]. MRCP has lower spatial resolution compared to conventional cholangiographic methods. Therefore, small ductal pathologies and peripheral bile ducts may not be observed. Another disadvantage is that it cannot be used for therapeutic purposes [12]. In our study, no significant differences were observed among MRCP findings, diagnoses, and bilirubin grades across all three imaging options.

Choledocholithiasis is the most common cause of obstruction in the extrahepatic bile ducts. MRCP and ERCP have similar accuracy rates in detecting choledocholithiasis. Many studies have shown the sensitivity of MRCP as 81 to 100% and the specificity as 85 to 100%. Gallstones appear as round or oval low-signal intensity filling defects in the bile duct. Stones with diameters 2-3 mm can be seen in MRCP [13]. Small gallstones may not dilate the bile ducts and are best seen on axial images. In the differential diagnosis of filling defects in the bile ducts, air bubbles, tumors, blood clots, metallic stents, surgical clip artifacts, and the ampullary appearance of the cystic duct opening into the main hepatic bile duct should be considered [14]. Air bubbles are seen in the non-dependent region of the bile ducts and often create air-fluid levels. Impacted stones in the ampulla region may be confused with stenosis due to the lack of peripheral hyperintense bile. In a case with a high suspicion of choledocholithiasis, if a stone is detected in the common bile duct by ultrasonography, ERCP should be performed to avoid delaying interventional procedures. MRCP is indicated in patients whose ultrasonography does not detect stones but who are clinically suspected to have common bile duct stones [15].

Cholangiocarcinoma is the most common primary malignant tumor of the bile ducts, located in the common bile duct in 30-36% of cases, in the common hepatic duct in 15-30% of cases, and in the biliary bifurcation in 10-26% of cases; seen as stenosis without a mass. MRCP has an essential role in perihilar cholangiocarcinomas. It is characterized by sudden biliary obstruction and dilatation of the bile ducts distally in MRCP. With conventional MR examination, the detection of the lesion, its spread, and its relationship with neighboring organs is more clearly revealed. MRCP has a sensitivity of 81-100% and a specificity of 93-94% in bile duct malignancies [16].

90% of malignant pancreatic neoplasms are adenocarcinomas of ductal origin. 62% of pancreatic carcinomas are located in the head of the pancreas, 26% in the body, and 12% in the tail [17]. Obstruction in the pancreatic and bile ducts, and dilation in the distal section are detected in MRCP. Dilation in the common bile and pancreatic ducts is an important finding (double duct sign). However, it is not specific to pancreatic cancer and can also be seen in chronic pancreatitis and ampullary tumors. In pancreatic head cancers, dilation is detected in both the bile and pancreatic ducts in 77%, in only the bile duct in 9%, and in only the pancreatic duct in 12% [18]. Our study's MRCP findings, imaging methods and indications, and bilirubin grades are based on four MRCP diagnoses. Cholecystitis was detected in 57.8% of patients with choledocholithiasis; tumor detected in only 5.8%. Gallstones were diagnosed with cholecystitis in 70.9% of cases; cancer

Table 3. Comparison of MRCP diagnoses with age and bilirubin levels

		Age (years)	Bilirubin total (mg/dL)	Bilirubin direct (mg/dL)
Cholecystitis				
	No (n=173)	68.5 (66.0-70.9)	4.12 (3.46-4.79)	3.03 (2.48-3.58)
	Yes (n=195)	70.7 (68.2-73.1)	3.58 (3.06-4.10)	2.55 (2.11-2.99)
	p-value	0.078	0.608	0.684
Gallbladder perforation				
	No (n=363)	69.6 (67.8-71.3)	3.85 (3.43-4.27)	2.79 (2.44-3.14)
	Yes (n=5)	78.6 (62.6-94.6)	2.95 (0.57-6.47)	1.72 (0.48-3.91)
	p-value	0.216	0.561	0.520
Acute pancreatitis				
	No (n=287)	70.1 (68.1-72.1)	4.17 (3.66-4.67)	3.06 (2.64-3.49)
	Yes (n=81)	68.2 (64.4-72.0)	2.67 (2.67-3.23)	1.76 (1.33-2.20)
	p-value	0.290	**0.001**	**0.001**
Tumor (glallbladder or klatskin)				
	No (n=326)	69.0 (67.1-70.9)	3.39 (3.02-3.75)	2.38 (2.08-2.68)
	Yes (n=42)	74.8 (71.3-78.2)	7.31 (5.20-9.43)	5.84 (4.09-7.58)
	p-value	0.090	**<0.001**	**<0.001**

MRCP: Magnetic resonance cholangiopancreatography

diagnosed in only 8.5%. Biliary duct dilatation was the most common finding in patients with tumors.

Although bile duct obstruction is present in 20% of cases, the width of the pancreatic duct is normal. The positive predictive value of MRCP in showing the cause of malignant bile duct obstruction is 86%, and the negative predictive value is 98%. Some recommend using ERCP as a diagnostic imaging method for malignant and benign strictures due to the similarity of their morphological features in MRI, increased spatial resolution, and the possibility of taking biopsies. In addition, ERCP is superior to MRCP in differential diagnosis, mainly because it can directly visualize ampullary region pathologies such as ampullary tumors, inflammatory stenosis, sphincter of Oddi dysfunction, and impacted stones [19]. Two essential factors in the etiology of acute pancreatitis are alcohol and gallstones. Performing ERCP during acute pancreatitis is not preferred because it may increase the severity of the disease. Therefore, MRCP has an essential role in revealing the etiology of the disease. It may indicate choledochal stones, pancreas division, pancreatic carcinoma, and pancreaticobiliary junction anomalies [20]. In acute pancreatitis, the choledochus is usually of normal width and ends by gradually thinning distally. Choledochal stones causing acute pancreatitis are mainly observed as filling defects. In conventional MRIs, focal or diffuse thickening of the pancreas, contour irregularity,

Table 4. Comparison of patients with no pathology detected in MRCP examination for gender, MRCP findings, imaging indication, imaging methods and bilirubin grades

		No pathology	At least one pathology	p-value
Gender	Female	66 (32.8)	135 (67.2)	0.919
	Male	54 (32.3)	113 (67.7)	
Choledocholithiasis	No	69 (32.2)	145 (67.8)	0.860
	Yes	51 (33.1)	103 (66.9)	
Gallstone	No	73 (47.1)	82 (52.9)	**<0.001**
	Yes	47 (22.1)	166 (77.9)	
Bile sludge	No	87 (35.7)	157 (64.3)	0.080
	Yes	33 (26.6)	91 (73.4)	
Biliary duct dilatation	No	49 (37.1)	83 (62.9)	0.167
	Yes	71 (30.1)	165 (69.9)	
Imaging indication	Biliary duct dilatation	47 (28.7)	117 (71.3)	0.286
	Choledochus stone	2 (40.0)	3 (60.0)	
	Gallstone	19 (33.9)	37 (66.1)	
	Mass	4 (23.5)	13 (76.5)	
	Other	39 (41.1)	56 (58.9)	
Ultrasound	No	90 (32.5)	187 (67.5)	0.933
	Yes	30 (33.0)	61 (67.0)	
CT	No	22 (31.0)	49 (69.0)	0.745
	Yes	98 (33.0)	199 (67.0)	
Imaging	No imaging	9 (29.0)	22 (71.0)	0.904
	USG or CT	94 (32.9)	192 (67.1)	
	USG and CT	17 (33.3)	34 (66.7)	
Bilirubin grade	<1 mg/dL	26 (40.6)	38 (59.4)	**0.040**
	1-2 mg/dL	14 (18.9)	60 (81.1)	
	2-5 mg/dL	52 (36.6)	90 (63.4)	
	5-10 mg/dL	19 (29.2)	46 (70.8)	
	>10 mg/dL	9 (39.1)	14 (60.9)	
Bilurubin total <2 mg/dL	<2 mg/dL	40 (28.8)	99 (71.2)	0.222
	>2 mg/dL	80 (34.9)	149 (65.1)	
Bilurubin total <5 mg/dL	<5 mg/dL	93 (33.1)	188 (66.9)	0.720
	>5 mg/dL	27 (31.0)	60 (69.0)	

MRCP: Magnetic resonance cholangiopancreatography, CT: Computed tomography, USG: Ultrasound

hyperintense signal change in T2-weighted images, and peripancreatic fluid collections may be observed. Diffuse compression secondary to edema in the pancreatic duct may be detected [21]. Chronic pancreatitis diagnostic criteria for chronic pancreatitis, in MRCP are characterized by multifocal dilatation, stenosis, and irregularity in the primary and side branch ducts. The most obvious and specific feature of chronic pancreatitis is side branch dilation. Irregularity of the pancreatic contour, pseudocysts, and ductal filling defects secondary to stones and debris can be seen. Stones up to 2 mm can be seen. ERCP, which has a higher spatial resolution, is more sensitive in revealing duct changes in the early stage. MRCP can be used to show chronic pancreatitis complications and monitor advanced cases [22].

ERCP is an invasive method that carries a mortality rate of 0.2-1% and a morbidity rate of 1-7%, and requires experienced operators: these factors makes it difficult to use for diagnostic purposes. MRCP is a reliable and non-invasive examination method for pancreatic and biliary system diseases. It does not require contrast material and allows multiplanar and cross-sectional imaging. Therefore, MRCP is preferred after USG. A comparative study of MRCP, CT, and USG in pancreaticobiliary system diseases found agreement between USG and MRCP in 92% of the cases. A statistically significant difference was found between the evaluations of extrahepatic bile ducts by USG and MRCP [23]. A study involving 106 patients compared axial and coronal 2D T2 TSE-suppressed sequences with 3D maximum intensity projection images. The accuracy of 2D T2 TSE sequences in detecting biliary system pathology was found to be 94% [24]. In another study conducted with 108 patients using respiratory-averaged 2D FSE sequences, the specificity of MRCP in detecting biliary system pathology was 97%, sensitivity was 99%, and accuracy was 98% [25]. In a study by Regan et al. [26], ERCP, MRCP, and US results were compared. The sensitivity and specificity values of USG, MRCP, and ERCP in detecting choledochal stones were 57% and 100% for USG, 87% and 75% for MRCP, and 100% for ERCP, respectively. In a study conducted by Fulcher et al. [27] on 300 cases using the Half-Fourier Acquisition Single-Touch Echo sequence, the sensitivity, specificity, and accuracy of MRCP in detecting choledochal stones were reported as 100%. In another study comparing MRCP, USG, and direct cholangiography in the detection of choledocholithiasis, the sensitivity, specificity, and accuracy rates were found to be 91%, 98%, and 97% for MRCP, and 38%, 100%, and 89% for USG, respectively [28]. In a study of 300 cases conducted by Fulcher et al. [27] using the Half Fourier Rapid Acquisition with Relaxation Enhancement sequence, the sensitivity of MRCP in the diagnosis of malignant obstructions was found to be 100%, specificity 97.6%, and accuracy 98.2%.

The most crucial advantage of MRCP in malignant pathologies is that it non-invasive ly, visualizes the bile and pancreatic ducts. Resectability and spread of a tumor can be evaluated by adding conventional MR sequences. In a study conducted with respiratory averaged 3D fat-suppressed T2 TSE sequence, the sensitivity, specificity, and accuracy of MRCP in detecting malignant and other pathologies were found to be 100% [29]. In a study conducted by Park et al. [30], the sensitivity, specificity, and accuracy rates of MRCP (81%, 70%, 76%) and ERCP (74%, 70%, 72%) in differentiating cholangiocarcinoma-related stricture from benign stricture were found to be respectively. The most commonly used non-invasive imaging method in patients with suspected bile duct obstruction is USG. The sensitivity of USG varies between 20% and 80% depending on its use, and its specificity is over 90%. Hussein et al. [31] reported the specificity, sensitivity, and accuracy of MRCP in diagnosing bile duct obstruction as 100%. The characteristics that limit the use of MRCP are its low-resolution power, inability to show small ductal pathologies, and lack of capability to perform therapeutic interventions during the procedure.

The logistic regression analysis revealed that age was significantly associated with pathology detection in MRCP, with older patients having a higher likelihood of positive findings (OR: 1.016, 95% CI: 1.003-1.029, p=0.017). This suggests that age may serve as an independent predictor of biliary pathology, reinforcing the importance of considering patient demographics when determining the necessity of advanced imaging. However, no significant association was found between gender, total bilirubin, and direct bilirubin levels and pathology detection. These results imply that bilirubin levels alone may not be a sufficient indicator for justifying MRCP in the emergency setting, highlighting the need for a more comprehensive clinical assessment before ordering advanced imaging. Future studies should further investigate the interplay of these variables and explore refined protocols to optimize MRCP utilization while maintaining diagnostic accuracy.

Table 5. Univariate and multivariate analysis of demographic and laboratory predictors of pathology detection in MRCP"

	Univariate logistic regression		Multivariate logistic regression	
	OR (95% CI)	p	OR (95% CI)	p
Age (years)	1.016 (1.003-1.029)	0.017	1.016 (1.003-1.029)	**0.017**
Gender	1.023 (0.660-1.585)	0.919	1.031 (0.660-1.610)	0.894
Bilirubin, total	0.991 (0.941-1.045)	0.749	1.077 (0.827-1.404)	0.581
Bilirubin, direct	0.985 (0.925-1.049)	0.638	0.898 (0.655-1.232)	0.506

OR: Odds ratio, CI: Confidence interval

Study Limitations

One of the significant limitations of this study is the scarce literature available on the use of MRCP in the ED. The lack of existing data detailing the characteristics, diagnostic and therapeutic characteristics and processes of ED patients undergoing MRCP makes it challenging to interpret our findings within a broader context. This limitation also restricts the generalizability of the study's results. However, the strengths of this study include a pioneering evaluation of the role of MRCP in a critical clinical setting such as the ED. This offers a valuable perspective that can serve as a foundation for future research. Additionally, by conducting a retrospective analysis of a large patient cohort, the study enables a practical assessment of the clinical impacts of MRCP in the ED. In this context, our study not only highlights the existing knowledge gap but also provides a starting point for further investigations in this field.

Conclusion

MRCP is a valuable non-invasive imaging modality for biliary pathologies in the ED. However, its routine use should be reconsidered given that 32.6% of MRCPs yielded normal findings. A protocol-driven approach may improve its utility while reducing unnecessary imaging. The findings of this study suggest that while MRCP is highly effective in diagnosing significant biliary pathology, its routine use in the ED should be approached with caution. The high proportion of normal MRCP findings indicates a potential for overuse, highlighting the need for more refined selection criteria. Additionally, cost-effectiveness should be considered when choosing MRCP over alternative imaging methods such as USG and CT, which may be sufficient in many cases. While MRCP offers superior diagnostic accuracy, especially for detecting choledocholithiasis, its cost and accessibility limit its widespread routine use. Future research should focus on developing optimized protocols that balance the clinical benefits of MRCP with economic constraints and patient outcomes.

Ethics

Ethics Committee Approval: Ethics committee approval has been granted by the Clinical Research and Ethics Committee of Giresun Training and Research Hospital (approval number: 02, date: 27.02.2023).

Informed Consent: Retrospective study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: İ.A., S.A., Concept: İ.A., S.A., Design: İ.A., S.A., Data Collection or Processing: İ.A., S.A., Analysis or Interpretation: İ.A., S.A., Literature Search: İ.A., S.A., Writing: İ.A., S.A.

Conflict of Interest: No conflict of interest was declared by the authors.

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ORIGINAL RESEARCH

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Comparison of GRACE, HEART and TIMI Scores in Predicting Major Adverse Cardiac Events in Patients Visiting the Emergency Department

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Abstract

Objective: Age, Risk factors, and Troponin (HEART), Thrombolysis in Myocardial Infarction (TIMI), and Score, and Global Registry of Acute Coronary (GRACE) Scores are critical for identifying patients at risk for major adverse cardiac events (MACE), guiding timely interventions, and optimizing resource utilization. This study aimed to evaluate the comparative utility of these three scoring systems in predicting MACE in patients visiting the emergency department (ED).

Materials and Methods: This prospective observational study included 502 adult patients visiting the ED with chest pain of a tertiary hospital between December 2014 and March 2015. HEART Score, TIMI, GRACE Score were evaluated for MACE over a 14-day and six-week, period. Data collected included demographic characteristics, clinical findings, laboratory results, and outcomes such as myocardial infarction, coronary angiography, revascularization, and mortality. Statistical significance was set at $p<0.05$.

Results: At 14-day follow-up, the HEART Score identified 192 patients as "low risk", of which 2.5% missed MACE. The GRACE Score identified 276 patients as "low risk", of which 10.5% missed MACE. The TIMI Score identified 288 patients as "low risk", of which 12.8% missed MACE. The area under the curve (AUC) for HEART Score, TIMI Score, and GRACE Score for 14-day MACE was calculated as 0.767, 0.678, and 0.674. In addition, the AUC for HEART Score, TIMI Score, and GRACE Score for MACE at 6-week follow-up was calculated as 0.700, 0.649 and 0.704.

Conclusion: The HEART Score demonstrates higher prognostic value for predicting MACE within 14 days than the TIMI and GRACE Scores in patients visiting the ED with chest pain. The TIMI Score has lower prognostic value for predicting MACE over a 6-week period compared to the HEART and GRACE Scores.

Keywords: TIMI Score, GRACE Score, HEART Score, chest pain, emergency department

Introduction

Chest pain is one of the most common major complaints in emergency departments (EDs) worldwide, representing a significant proportion of patient presentations. Rapid and accurate risk stratification of patients presenting with chest pain is crucial to identifying individuals at high risk for adverse cardiac events, such as myocardial infarction (MI), and guiding timely and appropriate management strategies. However, the heterogeneous etiologies and clinical presentations of chest pain pose a major challenge for emergency physicians (1).

ED visits have been increasing each year (2). In an overcrowded ED, the risk stratification of patients presenting with complaints such as chest pain is of critical importance for both ED management and patient care. To facilitate risk stratification, various clinical decision-making tools have been developed (3-5). Among these, the history, electrocardiography (ECG), Age, Risk factors, and Troponin (HEART)

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Score, the Thrombolysis in MI (TIMI) Score, and Global Registry of Acute Coronary Events (GRACE) Score have emerged as prominent and widely used tools (4). Each scoring system incorporates different clinical, laboratory, and historical parameters to estimate the likelihood of adverse cardiac outcomes (4,5). Despite their widespread use, consensus on the comparative utility and predictive accuracy of these scoring systems in the ED setting remains elusive. The HEART Score is specifically designed for rapid evaluation in the ED and provides a streamlined approach to categorizing patients into low, intermediate, and high-risk groups (6). The TIMI Score, originally designed for patients with unstable angina and non-ST-elevation MI (STEMI), offers a validated tool to assess risk over a 14-day period (7). In contrast, the GRACE Score provides hospital-based risk assessment for predicting adverse outcomes, including in-hospital mortality (8).

Given the differing methodologies and clinical contexts in which these scoring systems are applied, their comparative performance in the ED warrants rigorous investigation (9-11). This study aims to evaluate the effectiveness of the HEART, TIMI, and GRACE Scores in predicting major adverse cardiac events (MACE) in patients presenting with chest pain in the ED.

Materials and Methods

This prospective observational study was conducted in the ED of University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital from December 1, 2014, to March 1, 2015, following Ethical Approval (decision number: 2014/16/06, date: 24.11.2014). Adults aged 18 years and older presenting with chest pain were included in the study.

Study Implementation

A total of 502 patients visiting the ED with chest pain between December 1, 2014, and March 1, 2015, were included in the study. The HEART Score, TIMI Score, and GRACE Score were evaluated for MACE over 14-day and 6-week periods. MACE was defined as in-hospital mortality, new or recurrent MI, and ischemia requiring revascularization during this timeframe. Collected data included demographic characteristics (age, gender, and medical history), vital signs (heart rate, blood pressure, respiratory rate, body temperature, and oxygen saturation), imaging results (e.g., chest X-rays, CT scans), laboratory findings (e.g., hemoglobin, hematocrit, troponin levels), and outcomes such as coronary angiography, MI, bypass surgery, and mortality.

Inclusion Criteria

Patients aged 18 years and older who visited the ED with chest pain and provided informed consent were included in the study.

Exclusion Criteria

The following exclusion criteria were applied:

- Patients under 18 years of age.
- Chest pain secondary to trauma.
- Patients identified with STEMI during the initial evaluation.
- Patients with non-cardiac causes of chest pain (e.g., costochondritis, pulmonary embolism, pericarditis) during initial evaluation.
- Conditions such as sepsis, altered mental status, acute cerebrovascular disease, tachyarrhythmias, or cardiac arrest.
- Patients who refused to participate or did not present with chest pain.

Data Collection

Patients were initially assessed in the triage area under physician supervision by trained nurses or emergency medical technicians. Vital signs and 12-lead ECGs were recorded within the first 10 minutes after presentation. Detailed histories, physical examinations, and treatment plans were documented by emergency physicians. Clinical decision-making tools were blinded during treatment to avoid bias. Calculation of Risk Scores

- HEART Score: Calculated based on clinical history, ECG findings, risk factors, age, and initial troponin levels. Scores range from 0 to 10 and are categorized into low, intermediate, and high-risk groups (6).
- TIMI Score: Evaluated using seven variables, including age ≥65 years, known coronary artery disease, recent aspirin use, severe angina, elevated biomarkers, ST deviation, and risk factors for coronary artery disease (7).
- The GRACE Score: Uses eight variables, including age, heart rate, systolic blood pressure, creatinine levels, Killip class, ST deviation, cardiac biomarkers, and cardiac arrest at presentation. Scores were divided into low, intermediate, and high-risk groups (8).

Statistical Analysis

The data used in this study were analyzed using SPSS 21.0 for Windows® statistical software package (IBM Inc., Chicago, IL, USA). Descriptive statistics were presented as median (minimum-maximum) values, mean ± standard deviation for continuous variables, and frequencies and percentages for categorical variables. The normality of the distribution of continuous variables was assessed using the Kolmogorov-Smirnov test, followed by the application of parametric or non-parametric tests as appropriate. For comparisons between groups, the t-test was used when normality was met, while the Mann-Whitney U test was applied for non-normally distributed data. Within-group comparisons were performed using the Wilcoxon signed-rank test. For categorical variables, the Pearson chi-square test and Fisher's exact test were employed. A p-value of <0.05 was considered statistically significant.

Results

A total of 62,486 patients visited the ED between December 1, 2014 and March 1, 2015. Of these, 2,125 patients (3.4%) visited with complaints of chest pain. A total of 502 patients who met the inclusion criteria were included in the study. The study population comprised 227 women (45.2%) and 275 men (54.8%). Patient ages ranged from 18 to 92 years, with a mean age of 56.57±17.97 years. Age distribution revealed that 131 patients (26.1%) were younger than 45 years, 202 patients (40.2%) were between 45 and 65 years, and 169 patients (33.7%) were older than 65 years.

The mean vital signs at presentation were within normal ranges: systolic blood pressure 136±27 mmHg (range: 74-230), heart rate 89±25 bpm (range: 35-130), oxygen saturation 96±4.4% (range: 62-100), respiratory rate 17±4/min (range: 12-30), and body temperature 36.8±0.3°C (range: 36.0-39.7).

The most common coronary artery disease risk factors were male gender (54.8%), hypertension (44.8%), and smoking (41%). Additionally, a family history of coronary artery disease was identified in 185 patients (36.9%). The distribution of risk factors is shown in Figure 1.

HEART Risk Score Evaluation: Among the 502 patients, 197 (39.2%) were classified as low risk, 180 (35.9%) as intermediate risk, and 125 (24.9%) as high risk according to the HEART Score (Table 1). MACE was observed in 92 patients (18.1%) within 14 days. When patients were stratified according to the HEART Score, the incidence of MACE within 14 days was 2.5% (n=5) in the low-risk group, 23.9% (n=43) in the intermediate-risk group, and 34.4% (n=43) in the high-risk group (p<0.001) (Table 1).

Over a six-week follow-up, MACE occurred in 18.3% of low-risk, 38.3% of intermediate-risk, and 59.2% of high-risk patients (Table 2). Mortality rates were 1.01%, 2.22%, and 8% in the low-, intermediate-, and high-risk groups, respectively.

TIMI Risk Score Evaluation: Based on the TIMI Score, 288 patients (57.4%) were classified as low risk, 154 (30.7%) as intermediate risk, and 60 (12%) as high risk. When patients were stratified according to the TIMI Score, the incidence of MACE within 14 days was 12.8% (n=37) in the low-risk group, 22.1% (n=34) in the intermediate-risk group, and 33.3% (n=20) in the high-risk group (p<0.001) (Table 1). Over a six-week follow-up, MACE occurred in 28.1% of low-risk, 40.3% of intermediate-risk, and 60.0% of high-risk patients (Table 2). Mortality rates were 0.7%, 5.8%, and 8.3% in the respective groups.

GRACE Risk Score Evaluation: The mean GRACE Score was 108.11±45.02 (range: 23-302). Based on the GRACE Score, 276 patients (55.0%) were low risk, 98 (19.5%) were intermediate risk, and 128 (25.5%) were high risk. When patients were stratified according to the GRACE Score, the incidence of MACE within 14 days was 10.5% (n=29) in the low-risk group, 26.5% (n=26) in the intermediate-risk group, and 28.1% (n=36) in the high-risk group (p<0.001) (Table 1). Over a six-week follow-up, MACE occurred in 23.6% of low-risk, 38.8% of intermediate-risk, and 59.4% of high-risk patients (Table 2). Mortality was observed in one patient (0.7%) in the high-risk group.

The HEART Score showed a good prognostic value for 14-day MACE with an area under the curve (AUC) of 0.767. However, the AUC for 14-day MACE was calculated as 0.678 for the TIMI Score and 0.674 for the GRACE Score. The HEART Score showed a good prognostic value with an AUC of 0.700 for MACE at 6 weeks. Additionally, the AUC for MACE at 6-week follow-up was 0.649 for the TIMI Score and 0.704 for the GRACE Score (Figure 2).

Table 1. Distribution of major adverse cardiac events over 14 days among patients stratified by risk scores

Risk stratification	Major adverse cardiac events			
	Total, n (%)	None, n (%)	Yes, n (%)	p
HEART Score				
Low	197 (39.2)	192 (46.7)	55 (5.5)	<0.001
Intermediate	180 (35.9)	137 (33.3)	43 (47.3)	
High	125 (24.9)	82 (20.0)	47.3)	
TIMI Score				
Low	288 (57.4)	251 (61.1)	37 (40.7)	<0.001
Intermediate	154 (30.7)	120 (29.2)	34 (37.4)	
High	60 (12.0)	40 (9.7)	20 (22.0)	
GRACE Score				
Low	276 (55.0)	247 (60.1)	29 (31.9)	<0.001
Intermediate	98 (19.5)	72 (17.5)	26 (28.6)	
High	128 (25.5)	92 (22.4)	36 (39.6)	
Total	502 (100)	411 (100)	91 (100)	

HEART: Age, Risk factors, and Troponin, TIMI: Thrombolysis in Myocardial İnfarction (**TIMI**), and Score, GRACE: Global Registry of Acute Coronary

Table 2. Distribution of major adverse cardiac events over 6 weeks among patients stratified by risk scores

Risk Stratification	Major adverse cardiac events			
	Total, n (%)	No, n (%)	Yes, n (%)	p
HEART Score				
Low	197 (39.2)	161 (49.8)	36 (20.1)	<0.001
Intermediate	180 (35.9)	111 (34.4)	69 (38.5)	
High	125 (24.9)	51 (15.8)	74 (41.3)	
TIMI Score				
Low	288 (57.4)	207 (64.1)	81 (45.3)	<0.001
Intermediate	154 (30.7)	92 (28.5)	62 (34.6)	
High	60 (12.0)	24 (7.4)	36 (20.1)	
GRACE Score				
Low	276 (55.0)	211 (65.3)	65 (36.3)	<0.001
Intermediate	98 (19.5)	60 (18.6)	38 (21.2)	
High	128 (25.5)	52 (16.1)	76 (42.5)	
Total	502 (100)	379 (100)	123 (100)	

HEART: Age, Risk factors, and Troponin, TIMI: Thrombolysis in Myocardial Infarction and Score, GRACE: Global Registry of Acute Coronary

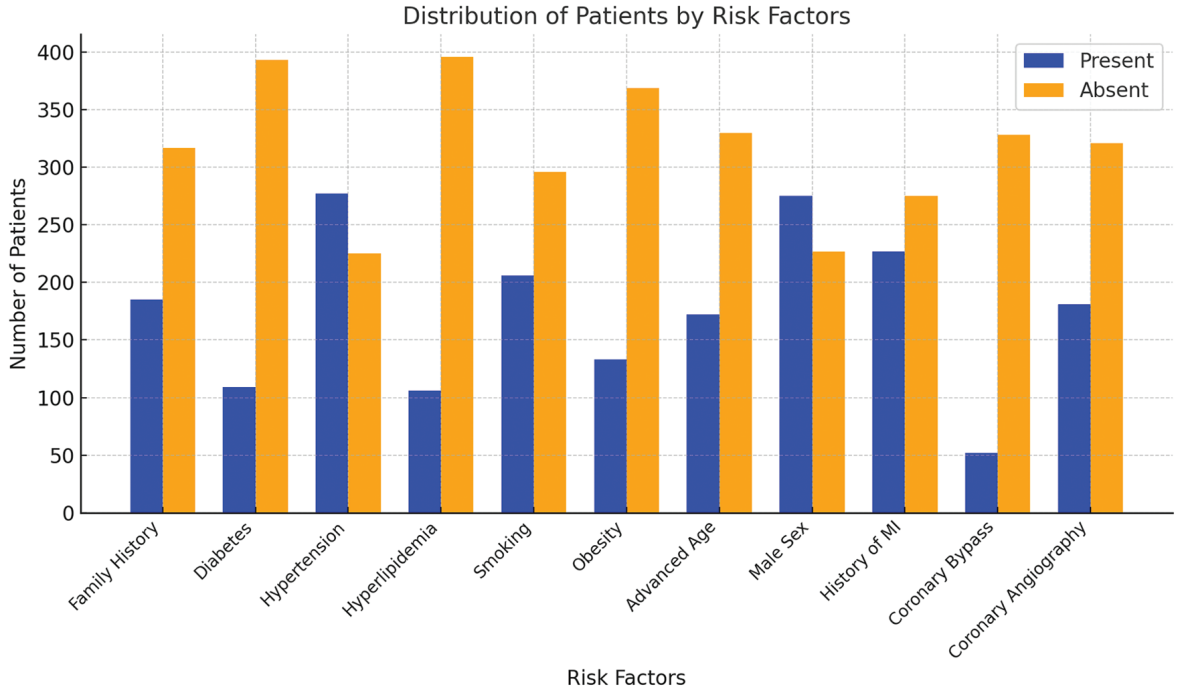

Figure 1. Distribution of risk factors for coronary artery disease

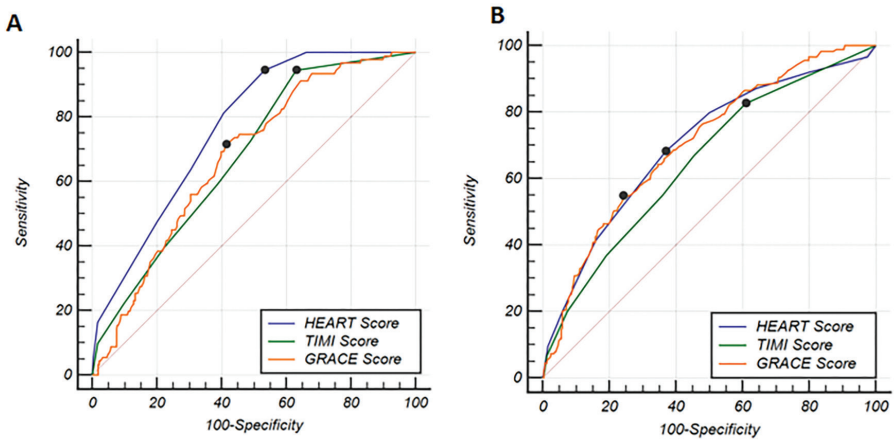

Figure 2. AUC of the HEART Score, GRACE Score, and TIMI Score for prediction of MACE at day 14 (A) and week 6 (B) in patients with chest pain. (A) The AUC for MACE at 14 days of follow-up shows a HEART Score of 0.767 (0.727 to 0.803), a TIMI Score of 0.678 (0.635 to 0.718), and a GRACE Score of 0.674 (0.632 to 0.715). B) AUC for MACE at 6 weeks follow-up HEART Score 0.700 (0.658 to 0.740), TIMI Score 0.649 (0.606 to 0.691), GRACE Score 0.704 (0.662 to 0.744)

HEART: Age, Risk factors, and Troponin, TIMI: Thrombolysis in Myocardial Infarction and Score, GRACE: Global Registry of Acute Coronary, AUC: Area under the curve, MACE: Major adverse cardiac events

Discussion

Chest pain, the second most common presenting complaint in the United States, accounts for 7.8 million ED visits annually (12). While only 5-13% of patients presenting to the ED with chest pain are diagnosed with acute coronary syndrome (ACS), a much larger proportion undergo prolonged ED observation or hospital admission to rule out ACS (13,14). Early diagnosis and timely intervention can significantly reduce morbidity and mortality rates and allow for more effective management of complications during follow-up. Various scoring systems used for risk stratification in patients presenting to the ED with chest pain provide clinicians with valuable assistance, particularly in assessing low-risk patients for ACS (3). This study evaluated the comparative effectiveness and utility of the HEART, TIMI, and GRACE Scores in predicting adverse cardiac outcomes in patients presenting to the ED with chest pain. A total of 502 patients were analyzed, and the risk stratifications and adverse cardiac outcome predictions of these three scoring systems were thoroughly assessed. The HEART Score is a predictive model designed for short-term risk stratification in suspected ACS patients (6). Developed in a Dutch Hospital, it incorporates history, ECG, HEART levels as MACE predictors (6,15). Our study confirms its effectiveness in MACE prediction. Adverse events were observed in 2.5% of the low-risk group, 23.9% of the moderate-risk group, and 34.4% of the high-risk group. Similarly, in a study by Six et al. (6) cardiac adverse outcomes were found in 2.5% of the low-risk group, (0-3%), 20.3% of the moderate-risk group, (4-6%), and 72.7% of the high-risk group, (7-10%). During a six-week follow-up, patients with higher HEART Scores had significantly higher rates of adverse cardiac outcomes (59.2%) compared to those in the low-risk group. The HEART Score has been evaluated by multiple independent research groups in both validation and clinical impact studies (15-17). Furthermore, the HEART Score has demonstrated superior performance compared to alternative predictive models in comparative studies (18,19). Additionally, the HEART Score is intuitive for emergency physicians, emphasizing clinical experience over statistically derived predictors commonly used in other models. A systematic review and meta-analysis of the HEART Score was published in May 2017 (20). The aim of this review was to summarize the evidence on the diagnostic accuracy of the HEART Score in predicting MACE in ED patients with possible ACS. The authors found an overall pooled prevalence of MACE of 15.4% during a mean follow-up of six weeks. Among 4,101 patients categorized as low-risk and suitable for early ED discharge (HEART Score 0-3), the pooled prevalence of MACE was 1.6%. The pooled sensitivity and specificity of the HEART Score for predicting MACE were 96.7% and 47.0%, respectively (20). In this study, the adverse cardiac event rates for low-, moderate-, and high-risk groups, as stratified by the TIMI Score, were 25%, 39.6%, and 58.3%, respectively. A study by Lakhani et al. (21) in 2008 evaluated 200 patients presenting to the ED. Severe coronary artery disease (defined as >70% stenosis) was identified, and early PCI was shown to be beneficial for patients with TIMI Scores >4. Although the TIMI Score is commonly utilized for assessing high-risk patients in the literature, its performance in predicting adverse cardiac events in low- and moderate-risk groups was limited in our study. Nevertheless, the TIMI Score contributes to risk assessment through its criteria, which include evaluating cardiac biomarkers and symptom duration. However, compared to the HEART Score, the TIMI Score was found to be less effective in predicting adverse cardiac events. The GRACE Score demonstrated moderate performance

in predicting both in-hospital and long-term adverse cardiac outcomes in this study. MACE rates for the low-, moderate-, and high-risk groups were 12.8%, 22.1%, and 33.3%, respectively. A study by van der Zee et al. (22) highlighted the GRACE Score's strong predictive ability for long-term cardiovascular mortality. The GRACE Score was particularly effective in predicting adverse cardiac outcomes in high-risk patients. However, the need for more data and the complexity of GRACE Score calculations limit its utility in ED settings. The comparison of HEART, TIMI, and GRACE Scores highlighted the differing effectiveness of these three systems in various patient groups. The HEART Score was deemed the most practical scoring system in the ED due to its ease of calculation and clinical applicability. The TIMI and GRACE Scores, on the other hand, provided additional value, particularly in identifying high-risk patients. These findings suggest that the HEART Score provides superior performance in predicting adverse cardiac outcomes and may serve as a primary evaluation tool in the ED.

Study Limitations

This study has several limitations. First, it was conducted at a single center, and the results may not be generalizable to different patient populations. Second, the six-week follow-up period may be insufficient for assessing long-term outcomes. Finally, differences in the timing of biomarker measurements and patient management could have influenced the results.

Conclusion

The HEART, TIMI, and GRACE Scores play a significant role in risk stratification in the ED. The HEART Score, in particular, demonstrated high performance in predicting adverse cardiac outcomes and may be prioritized in ED applications. However, all three scores are complementary in patient management and should be selected based on the clinical context. Future multicenter studies with broader patient populations are recommended to further evaluate the effectiveness of these scoring systems.

Ethics

Ethics Committee Approval: University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital from December 1, 2014, to March 1, 2015, following Ethical Approval (decision number: 2014/16/06, date: 24.11.2014).

Informed Consent: Informed consent was obtained.

Footnotes

Authorship Contributions

Surgical and Medical Practices: H.Y., Concept: H.Y., H.D., Design: H.Y., S.I., H.D., Data Collection or Processing: H.Y., S.I., Analysis or Interpretation: H.Y., H.D., Literature Search: H.Y., S.I., H.D., Writing: H.Y., S.I.

Conflict of Interest: No conflict of interest was declared by the authors.

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ORIGINAL RESEARCH

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Evaluation of Patients Visiting the Emergency Department by Ambulance; a Prospective Observational Study

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Abstract

Objective: The inappropriate utilization of ambulance services for non-emergent situations represents a global concern, negatively impacting response times, healthcare costs, and the workload of emergency medical services (EMS) personnel. This study aimed to assess the appropriateness of ambulance use by analyzing physical examination findings, hospitalization rates, and mortality outcomes among patients transported to the emergency department (ED) by ambulance.

Materials and Methods: This prospective study included patients aged 14 years and older who were transported to the ED of Bakırköy Dr. Sadi Konuk Training and Research Hospital by ambulance teams between September 1, 2015, and September 30, 2015. Exclusion criteria comprised children under 14 with non-traumatic complaints, pregnancy-related conditions, isolated trauma cases, and patients referred from other facilities. Data on demographic characteristics, clinical parameters, and patient outcomes were collected and subjected to statistical analysis.

Results: Among the 17,997 patients presenting to the ED, 4.4% were transported by ambulance, of whom 60.4% were male. The discharge rate was 67.3%, the intensive care unit admission rate was 12%, and the ward admission rate was 15.9%. A total of 48.3% of patients were categorized as critical based on ED triage systems. Despite this classification, the majority of patients exhibited normal vital signs and physical examination findings.

Conclusion: The findings of this study indicate that most patients transported to the ED by ambulance had normal vital signs and were subsequently discharged. Addressing the issue of ambulance misuse through targeted public education campaigns and enhanced access to primary care services is imperative to ensure the optimal utilization of EMS resources.

Keywords: Ambulance, emergency department, diagnosis, discharge, triage

Introduction

Emergency medical services (EMS) are essential for providing timely care to individuals facing life-threatening conditions. Ambulance systems, a critical component of EMS, are designed to ensure rapid response and transportation to appropriate healthcare facilities. However, the misuse of ambulance services for non-emergency situations has become a significant concern worldwide [1-3].

Inappropriate use of ambulance systems includes calls for minor ailments, transportation convenience, or non-urgent medical needs that could be addressed through primary care or outpatient services [4]. Such misuse leads to delayed response times for critical cases, unnecessary financial burdens on healthcare systems, and increased workload for EMS personnel, potentially resulting in burnout and decreased efficiency. Studies have shown that inappropriate ambulance use accounts for a substantial percentage of total ambulance use in various

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countries, including the United States (USA), Canada, Sweden, and England [5]. Understanding the factors contributing to this problem is essential for developing effective interventions. These factors may include lack of public awareness about appropriate EMS use, limited access to primary care services, and perceptions of ambulance services as a free or easily accessible resource. Research indicates that socioeconomic characteristics of users are related to ambulance misuse or overuse [5].

Despite numerous steps being taken to address this issue, there remains a significant need for scientific studies that shed light on the misuse of ambulance services. While EMS are rapidly advancing in our country, a review of the literature, reveals that the number of scientific studies on this topic is quite limited [5-8].

This study aimed to assess patient outcomes, including hospitalization, discharge, and mortality, among individuals transported to the emergency department (ED) by ambulance services. Additionally, we sought to evaluate the appropriateness of ambulance utilization in these cases.

Materials and Methods

Ethical Approval

This study was approved by the Bakırköy Dr. Sadi Konuk Training and Research Hospital Ethics Committee (approval number: 2015/14/21, date: 31.08.2015). All procedures were conducted in accordance with ethical guidelines and the principles of the Declaration of Helsinki.

Written informed consent was obtained from all patients included in the study. For patients who were unable to provide consent themselves (i.e., individuals under 18 years of age or those with clinically inadequate general condition), written consent was obtained from their legal guardians.

Study Population and Design

This prospective study included patients aged 14 years and older who were brought to the Emergency Medicine Clinic of Bakırköy Dr. Sadi Konuk Training and Research Hospital by ambulance teams between September 1, 2015, and September 30, 2015. Patients under the age of 14 brought in for non-traumatic complaints, patients presenting with pregnancy-related complaints, patients with isolated extremity trauma treated directly by the orthopedic department, and patients transferred from another facility with a prior diagnosis via transfer ambulance were excluded from the study. Patient information was obtained from transfer forms, ED records, discharge summaries, and the hospital information system database.

Data Collection

Data on patients brought in by ambulance, including name, age, date and time of arrival, reasons for emergency ambulance requests, physical examination findings, and vital signs recorded by the ambulance teams, were documented in the study form. Final diagnoses, discharge methods, and discharge date and time were retrieved from ED files and the hospital information system. Data were categorized and recorded in Microsoft Office Excel 2007 (Microsoft Co., New York, USA). Patient demographic information, including gender and age, was obtained from the hospital information system. Patient ages were analyzed in groups.

Pupil examination results were categorized as normal, miotic, mydriatic, non-reactive, anisocoric, or fixed and dilated. Glasgow Coma Scale (GCS) scores were recorded and grouped as mild (score 14-15), moderate (score 9-13), and severe (score 3-8). Skin findings were classified as normal, pale, cyanotic, moist, dry, or hyperemic. Mean arterial pressures were calculated with the formula [systolic + (2 × diastolic)]/3. Pulse rates were categorized as bradycardia (<60 bpm), normal (60-100 bpm), or tachycardia (>100 bpm). Respiratory rates were grouped as bradypnea (0-11 n/minute), normal (12-24 n/minute), or tachypnea (≥25 n/minute). Final diagnoses and discharge outcomes were obtained from the hospital information system and categorized as discharge, ward admission, intensive care admission, treatment refusal, unauthorized leave, or death.

Statistical Analysis

The data utilized in the study were analyzed using the SPSS 16.0 for Windows® statistical software package (IBM Inc., Chicago, IL, USA). The normality of the distribution of continuous variables was assessed using the one-sample Kolmogorov-Smirnov test; after which parametric and non-parametric tests were applied as appropriate. For comparisons between groups, the t-test and Mann-Whitney U test were used, while the Wilcoxon signed-rank test was applied for within-group comparisons. For categorical variables, Pearson's chi-square test, one-sample chi-square test, and Fisher's exact test were employed. Descriptive statistics included minimum and maximum values, arithmetic mean ± standard deviation for continuous variables, and frequencies and percentages for categorical data. A p-value of <0.05 was considered the threshold for statistical significance

Results

In our study covering September 2015, a total of 17,997 patients presented to our ED, of whom 793 were transported by EMS ambulances. The proportion of patients brought in by EMS to the total patient population was found to be 4.4%. Among the 793 patients included in the study, 60.4% (n=479) were male, and 39.6% (n=314) were female, resulting in a male-to-female ratio of 1.5:1 ($p<0.001$). The mean age of the patients was 53.9±23.16 years. The mean age of male patients was 49.24±22.75 years, while the mean age of female patients was 61.1±21.94 years. When assessing age groups, patients aged

18-65 years comprised 56.8% (n=451) of the presentations. It was observed that only 2.4% of the patients arrived by private healthcare emergency ambulances.

An analysis of the characteristics of the cases revealed that 24.3% (n=193) were forensic cases. By analyzing patient admissions by 8-hour time periods, the busiest period was identified as the evening hours (16:01-00:00), accounting for 42.0% (n=333) of admissions. When evaluating the presenting complaints, vital signs, clinical conditions, and distribution of patients by their admission rooms, it was found that the proportion of critical patients taken to the T1 room was 48.1% (n=383) (Table 1).

We also examined the physical examination findings and vital signs of the patients, based on their clinical conditions, admitted to triage rooms. When evaluating pupil reactions, it was found that 95.1% of the patients (n=754) had normal reactions, 1.3% (n=10) were miotic, 2.0% (n=16) were mydriatic, 1.0% (n=8) were anisocoric, 0.4% (n=3) were non-reactive, and 0.3% (n=2) had fixed dilated pupils. Among the 793 patients with recorded skin findings in our ED, 84.7% (n=672) had normal findings, 5.9% (n=47) were pale, 3.9% (n=31) were moist, 0.3% (n=2) were hyperemic, 0.5% (n=4) were icteric, 2.0% (n=16) were cyanotic, and 2.6% (n=21) were dry (Table 2).

The GCS scores were categorized as mild (14-15), moderate (9-13), and severe (≤8), and a comparative analysis was conducted between the GCS values assessed by EMS teams and those determined in our ED. Among patients classified as having severe GCS scores in the ED, 75% (n=21) were also categorized as "severe" by the EMS teams, while 10.7% (n=3) were assessed as "moderate" and 14.3% (n=4) as "mild." For patients classified as having moderate GCS scores in the ED (n=35), 11.4% (n=4) were evaluated as "severe," 42.9% (n=15) as "moderate," and 45.7% (n=16) as "mild" by EMS teams. Of the 611 patients categorized as having mild GCS scores in the ED, 95.7% (n=585) were similarly classified as "mild" by EMS teams, while 4.3% (n=16) were categorized as "moderate." Notably, none of the patients classified as "mild" in the ED were assessed as "severe" by EMS teams. The observed discrepancies in GCS classifications between EMS teams and the ED were statistically significant ($p<0.001$, $\kappa=0.566$) (Table 3).

Table 1. Baseline characteristics of patients

Baseline characteristics	n (%)
Age (years)	
0-18 years	37 (4.8)
19-64 years	451 (56.8)
≥65 years	305 (38.4)
Ambulance agency	
Public emergency medical services	774 (97.6)
Private healthcare	19 (2.4)
Emergency department arrival time	
00.01-08:00	157 (19.8)
08:01-16:00	303 (38.2)
16:01: 24:00	333 (42.0)
Triage	
1	383 (48.3)
2	220 (27.7)
3	133 (16.8)
4	53 (6.7)
5	4 (0.5)

Table 2. Distribution of physical examination findings

Physical examination findings	n (%)
Pupillary reflexes	
Normal	754 (9.2)
Miotic	10 (1.3)
Mydriatic	16 (2.1)
Anisocoric	8 (1.2)
Non-reactive	3 (0.1)
Fixed dilated	2 (0.1)
Skin findings	
Normal	672 (84.7)
Pale	47 (5.9)
Moist	31 (3.9)
Hyperemic	2 (0.3)
Icteric	4 (0.5)
Cyanotic	16 (2.0)
Dry skin	21 (2.6)

Table 3. Comparison of the distribution of patients according to GCS according to EMS-ED

Mild		Distribution of patients according to ED triage			Total
		Moderate	Severe		
Distribution of patients according to EMS triage	Mild	21 (75.0)	4 (11.4)	0	25 (3.7)
	Moderate	3 (10.7)	15 (42.9)	26 (4.3)	44 (6.5)
	Severe	4 (14.3)	16 (45.7)	585 (95.7)	605 (89.8)
Total		28 (4.2)	35 (5.2)	611 (90.6)	674 (100)

GCS: Glasgow Coma Scale, EMS: Emergency medical services, ED: Emergency department

The respiratory rates, mean arterial pressures, and pulse rates of patients brought to our ED by emergency ambulances were evaluated. The average respiratory rate of all patients was 19.47±5.51 breaths per minute, the average mean arterial pressure measured in the ED was 92.25±18.28 mmHg, and the average pulse rate was 87.06±19.74 beats per minute. It was found that 85.9% (n=681) of the patients had a respiratory rate between 12 and 20 breaths per minute. Additionally, 42.4% (n=381) were normotensive, and 72.2% (n=596) had a pulse rate within the normal range (Table 4).

Table 4. Distribution of patients based on vital parameters

Vital parameters	n (%)
Respiratory rate	
Bradipne (0-11)	12 (1.5)
Normal (12-20)	681 (85.9)
Takipne (≥20)	100 (12.6)
Mean arterial pressures	
Hypotensive	65 (8.2)
Normotensive	336 (42.4)
Slightly elevated	246 (31.0)
High	94 (11.9)
Very high	52 (6.5)
Pulsa rate (n/dk)	
No pulse	1 (0.1)
Bradycardic (<60 bpm)	42 (5.3)
Normal (60-100 bpm)	596 (75.2)
Tachycardic (>100 bpm)	154 (19.4)

Table 5. Distribution of patients based on emergency department outcomes

ED outcomes	n	%
Discharged	534	67.3
ICU admission	100	12.6
Exitus	8	1.0
DAMA from the ED	27	3.4
Inpatient admission	126	15.9
Internal medicine	31	3.9
Neurosurgery	6	0.8
Gastroenterology	11	1.4
Urology	4	0.5
Neurology	14	1.8
Orthopedics	25	3.2
Cardiovascular surgery	4	0.5
General surgery	21	2.6
Pulmonology	3	0.4
Thoracic surgery	1	0.1
Otolaryngology	1	0.1

DAMA: discharge against medical advice, ED: Emergency department, ICU: Intensive care unit

When we examined the wards to which patients brought to the ED by ambulances were admitted, it was observed that 67.3% (n=534) of the patients were discharged from the ED, 12.0% (n=95) were admitted to the intensive care unit (ICU), and 15.9% (n=126) were admitted to inpatient wards (Table 5).

Discussion

In our study, the proportion of patients presenting to the ED via ambulance was found to be 4.4%. In similar studies conducted in Türkiye, this rate was reported to range between 1.3% and 4.0% [9-11]. While our data align with national figures, studies conducted abroad have shown higher rates of ambulance usage. A 2003 study in the USA reported that 14% of 114 million ED visits were made by ambulance [3]. Similarly, Nawar et al. in a 2005 study, stated that 15.5% of ED visits were ambulance arrivals [12]. ED visits and the number of emergency surgical procedures performed in Türkiye are steadily increasing [13,14]. The lower rates observed in Türkiye compared to the USA and European countries might be attributed to non-emergency patients frequently using emergency services for free, unscheduled healthcare.

When examining the age distribution of patients brought in by ambulance, we found that the majority (56.8%) were in the 18-65 age group. Kıdak et al. [15] reported in their study that 26.7% of all ambulance transports involved patients aged 65 and older. Similarly, Nur et al. [16] found that 22.2% of emergency calls to the 112 ambulance service involved patients aged 65 and older. Yurteri et al. [17], in their study conducted in Bursa, reported that patients aged 60 and older constituted 48% of ambulance arrivals. Victor et al. [18], in a London-based study, stated that 40% of all ambulance calls were made by patients aged 60 and older. Our data align with the literature.

In our study, the average respiratory rate was 19.47±5.51 breaths per minute. Özüçelik et al. [19], in their study comparing Hospital Admission Triage System and Emergency Severity Index triage systems, calculated the average respiratory rate as 17.3±12.99. The mean arterial pressure in our study was 92.25±18.28 mmHg, while Özüçelik et al. [19] reported it as 86.8 mmHg. The average pulse rate in our study was 87.06±19.74 beats per minute, compared to 88.6±16.62 reported by Özüçelik et al. [19]. Evaluations in non-physician-staffed ambulances, as well as rapid on-site examinations, are prone to errors and changes in clinical findings during transport to the ED should be considered. Thus, vital signs and examinations performed by EMS teams should be conducted with greater precision. Moreover, patients should undergo detailed examinations upon arrival at the ED, and these should be repeated periodically. Additionally, derived severity scores can be utilized to assess patients' conditions [20,21].

In our study, 67.3% of the patients brought in by ambulance were discharged, 27.2% were admitted, and 1.0% died. Of those admitted, 44.2% were placed in ICUs, and 55.8% were admitted to inpatient wards. Önge et al. [22] reported that 74.9% of patients brought to the ED via ambulance were discharged after evaluation and treatment, while 24.1% were admitted; of these, 61.1% were placed in ICUs and 38.9% in inpatient wards. Similarly, Çelik et al. [11] reported that 87.2% of ambulance patients were discharged, 0.8% died, and 11.9% were admitted; of those admitted, 34.5% were placed in ICUs and 65.5% in inpatient wards. Kılıçaslan et al. [23] found that 86.2% of patients were discharged from the ED, 12.5% were admitted, 0.8% refused treatment, and 0.3% died.

Tanrıkulu et al. [24] reported admission rates of 42.3% to internal medicine wards, 47.5% to surgical wards, and 10.2% to ICUs. Among patients admitted to internal medicine wards, 33.2% were in cardiology, 19.5% in neurology, and 13% in general internal medicine. For surgical wards, 25.5% were in general surgery, 23.8% in orthopedics, and 16.2% in neurosurgery. Kılıçaslan et al. [23] reported that the departments with the highest admission rates were cardiology (21.0%), internal medicine (15.1%), and orthopedics (11.2%).

In our hospital, which employs a complaint-based five-level triage system (T1, T2, T3, T4, T5), 48.3% of patients brought in by ambulance were admitted to the T1 room, 27.7% to the T2 room, 16.8% to the T3 room, 6.7% to the T4 room, and 0.5% (n=4) to the T5 room. Aydın et al. [25], using a three-level triage system, reported that 16.5% of patients fell into the "critical" (T1) category, 21.2% into "urgent" (T2), and 62.3% into "non-urgent" (T3). Çevik et al. [26] classified 24.34% of ED patients into the green area, 75.20% into the yellow area, and 0.47% into the red area, based on urgency. A Danish study conducted in 2013 reported that, based on four months of data, 32.9% of emergency patients were in the green area (T4), 39.7% in the yellow area (T3), 26.9% in the orange area (T2), and 0.4% in the red area (T1) [27]. Kılıçaslan et al. [21] using a three-level triage system found that 10.4% of patients were in T1, 42.3% in T2, and 47.2% in T3. Esmailian et al. [28] in a study comparing five-level triage systems reported that 1.8% of patients were admitted to T1, 24.0% to T2, 68.1% to T3, 4.5% to T4, and 1.7% to T5. It has been reported that triage codes influence physicians' approach to patients in the ED [29]. We believe that the variation in data reported in the literature is due to the use of different triage systems, including two-level, three-level, four-level, and five-level systems.

Study Limitations

This study was conducted at a single center. Patients under the age of 14 with non-traumatic complaints, those with pregnancy-related complaints, and those with isolated extremity trauma directly admitted followed up in the orthopedics department were excluded from the study because they were admitted to different departments and their data were unavailable.

Conclusion

In our study, it was determined that the vast majority of patients presenting to the ED via ambulance had normal physical examinations and vital signs. Additionally, most of these patients were discharged from the ED.

Ethics

Ethics Committee Approval: This study was approved by the Bakırköy Dr. Sadi Konuk Training and Research Hospital Ethics Committee (approval number: 2015/14/21, date: 31.08.2015). All procedures were conducted in accordance with ethical guidelines and the principles of the Declaration of Helsinki.

Informed Consent: Written informed consent was obtained from all patients included in the study. For patients who were unable to provide consent themselves (i.e., individuals under 18 years of age or those with clinically inadequate general condition), written consent was obtained from their legal guardians.

Footnotes

Authorship Contributions

Surgical and Medical Practices: Ş.I., H.Y., Concept: Ş.I., D.N.Ö., Design: Ş.I., D.N.Ö., Data Collection or Processing: Ş.I., H.Y., Analysis or Interpretation: Ş.I., D.N.Ö., Literature Search: Ş.I., H.Y., Writing: Ş.I., H.Y., D.N.Ö.

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ORIGINAL RESEARCH

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Methanol Poisoning - Outbreak Dynamics and Therapeutic Uncertainties in Rural India

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Abstract

Objective: Methyl alcohol poisoning in India occurs as explosive outbreaks with mortality rates reaching 20%. Rural hospitals are often ill-equipped and lack expertise in handling such crises. The purpose of this work is to emphasize our experience regarding outbreak dynamics, clinical triage, sociocultural influences impacting treatment, and mortality predictors.

Materials and Methods: This was a hospital-based retrospective descriptive study conducted on 58 methanol poisoned adult patients who were admitted between 14th-16th May 2023. All patients had consumed methyl alcohol adulterated liquor on 13th May 2023, and were admitted to the emergency department at varying time periods. The main outcomes studied were death and permanent visual impairment.

Results: Among 58 victims, 49.2±13.1 years was the mean age. Of the patients, 86.20% were admitted within 48 hours of symptoms, with the median time to admission being 12-24 hours from consumption. The most common presenting symptoms were giddiness (32.75%) and abdominal pain (31.03%). Significant clinical parameters associated with mortality were altered consciousness, shock, and severe acidosis. 85.71% of patients with severe acidosis either succumbed or suffered permanent visual damage. The case fatality rate was 15.51%. Death peaked around 24 to 30 hours (55.56%). The median time to death from consumption was 40 hours, and 78% died by 48 hours.

Conclusion: Methanol poisoning in India is commonly due to adulterated liquor consumption. Baseline triage tools include pH, mental status assessment, respiratory distress, and hemodynamic instability. Ethanol treatment is fraught with risks and might not be socially acceptable. Future outbreaks should be anticipated. Every tertiary care hospital should have standard operating procedures in place and maintain an emergency stock of fomepizole.

Keywords: Methanol poisoning, outbreak, mortality predictors, treatment

Introduction

Methyl alcohol overdosage plagues almost every country on the globe [1]. However, the dynamics of poisoning differ significantly between countries. Whereas in developed nations sporadic cases occur infrequently, in India point source outbreaks are a common occurrence [2]. Consumption of adulterated liquor is the root cause. The dynamics of such an outbreak needs special mention. Outbreaks are explosive, flooding the nearest healthcare facility, which is often ill-equipped to handle the load. What is worse is that mortality ensues with frightening rapidity unless the health care team is triage-trained and has adequate infrastructural support.

Crude mortality rates for methanol poisoning hover between 18-44% [3,4]. The lethal dose has been reported as 50-500 mL [5,6]. A common cause of death appears to be severe acidosis and respiratory failure [7]. The only reliable laboratory markers

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of severity are serum methanol or formic acid levels, which are expensive and require infrastructure and expertise [8,9]. Point-of-care tests with both clinical and laboratory applications with early prognostic capacity are essential to triage patients.

We, at a rural tertiary care hospital, experienced one such outbreak in May of 2023, pushing the entire hospital into crisis mode. A retrospective analysis was conducted in its aftermath, which yielded valuable information to manage future eventualities. We aimed to share our experience with the scientific community with special emphasis on clinical presentation, sociocultural influences that impact treatment, and probable predictors of mortality. We also hope to create awareness among primary care physicians about the lethality of methanol poisoning and feasible treatment strategies in a resource-limited facility.

Materials and Methods

Electronic and manual case records of 58 patients admitted between the 14th and 16th of May 2023 for methanol poisoning were scrutinized for clinical and laboratory data. The outbreak dynamics such as mean time delay for hospital presentation, peak admission rates, mortality peak time, and average time to discharge were documented. Clinical features documented include presenting symptoms, consciousness state, vital signs, systemic and visual examination findings, complications, and treatment provided. Lab parameters documented include complete blood count, biochemical profile, including electrolytes, liver function tests, and arterial blood gas (ABG) analysis. Patients with severe acidosis were defined as those with a pH less than 7.2 at initial examination. Patients were triaged and managed using injection thiamine, injection pyridoxine, injection vitamin B12, tablet folic acid, and alkaline diuresis with injection. Sodium bicarbonate and crystalloids as per standard recommendations. Those with severe acidosis and depressed mentation underwent intermittent hemodialysis.

Ethical Consideration

The study was approved by the Government Villupuram Medical College and Hospital Institutional Ethics Committee (approval number: GVMC/IEC/2023(2)/3, date: 12.12.2023).

Statistical Analysis

Statistical analysis consisted of the Student's t-tests for independent variables and odds ratios, wherever appropriate. Univariate analysis determined the correlation between various tested laboratory investigations and the outcome. Values that showed significant association with mortality on univariate analysis were included in the multiple linear logistic regression model with death as the dependent variable and all associated parameters as independent variables. Statistical analysis was performed using SPSS, version 16 (SPSS, Inc). Statistical significance was set at 0.05.

Result

A total of 58 victims were admitted for consumption of methanol-adulterated liquor. 49.2±13.1 years was the mean age of the patients. Thirty-six (62.06%) developed symptoms within 24 hours of consumption. Fifty (86.20%) were admitted within 48 hours of symptoms; the median time to admission was 12 to 24 hours from consumption. The most common presenting symptoms were giddiness [19 (32.75%)] and abdominal pain [18 (31.03%)]. Triage done at baseline identified 14 patients as critically ill, and these patients were relocated to the intensive care unit (ICU). (8/14) 57.14% of ICU patients suffered mortality, whereas (1/44) 2.27% of non-ICU patients succumbed; the comparison was statistically significant ($p<0.01$). Eight (13.79%) patients had late manifestations (>48 hours) after consumption. The case fatality ratio for this outbreak was 15.51% (9/58). Death peaked around 24-30 hours (55.56%). The median time to death from consumption was 40 hours and 78% died by 48 hours. Significant clinical parameters associated with mortality were altered consciousness, shock, and severe acidosis (Table 1). Lab data included pH <7.2 in 12.07%, electrocardiogram abnormalities in 15.51%, and biochemical alterations in 21/58 or 36.21% of patients. Excluding pH, none were statistically significant. (6/7) 85.71% of patients with severe acidosis succumbed to the illness. The only survivor with pH <7.2 suffered severe morbidity [permanent visual damage (light perception or movement perception only)]. The methanol-poisoned patient with a baseline pH of <7.2 had a 96-fold higher chance of dying than his counterpart with pH >7.2.

Discussion

Although methanol itself is not highly toxic, it is metabolized by alcohol dehydrogenase (ALD) to form toxic metabolites formaldehyde and formic acid, which culminate in metabolic acidosis, blindness, cardiovascular instability, and death [10]. Formic acid, which is the major circulating metabolite, appears to be the key factor responsible for toxicity and death [11]. Inhibition of ALD and, in selected patients, hemodialysis are the traditional treatments for methanol poisoning.

Methanol poisoning in India occurs commonly as point source outbreaks [4,12]. The outbreak at Villupuram affected 58 persons, claimed 9 lives, and left 2 permanently blind. From a clinical standpoint, the time lag between consumption and presentation ranged from 6 to 60 hours, with peak admission rates occurring at 12-24 hours (21 patients) (Figure 1). 86.21% of victims presented within 48 hours of consumption. The implication is to activate and pool the best available resources in this time frame, in the event of future outbreaks. Notable clinical manifestations included giddiness (32.75%), abdominal pain (31.03%), and altered mentation (25.86%). However, only depressed mentation [odd ratio (OR): 48], shock (OR: 0.03), and respiratory distress (OR: 0.07) correlated with mortality.

Table 1. Clinical features and laboratory profile of methanol-poisoned inpatients at a tertiary care hospital and their correlation with outcome

Variables		Alive	Dead	OR	Significance
Headache	Yes	7 (77.8%)	2 (22.2%)	0.58	0.61
	No	42 (85.7%)	7 (14.3%)		
Giddiness	Yes	17 (89.4%)	2 (10.6%)	1.86	0.51
	No	32(82.1%)	7 (17.9%)		
GCS <8	Yes	7 (46.7%)	8 (53.3%)	48	<0.001
	No	42 (97.7%)	1 (2.3%)		
Vomiting	Yes	8 (80%)	2 (20%)	0.68	0.646
	No	41(85.4%)	7 (14.6%)		
Abdominal pain	Yes	17 (94.4%)	1 (5.6%)	4.25	0.249
	No	32 (80%)	8 (20%)		
Dyspnoea	Yes	4 (44.4%)	5 (55.6%)	0.07	0.003
	No	45 (91.8%)	4 (8.2%)		
Shock	Yes	3 (33.3%)	6 (66.7%)	0.03	<0.01
	No	46 (93.9%)	3 (6.1%)		
Diarhoea	Yes	1 (33%)	2 (67%)	0.07	0.06
	No	48 (87%)	7 (13%)		
Palpitation	Yes	3 (75%)	1 (25%)	0.52	0.61
	No	46 (85.2%)	8 (14.8%)		
Hemiodialysis	Yes	13 (81.3%)	3 (18.7%)	1.39	0.68
	No	36 (85.7%)	6 (4.8%)		
ECG abnormality	Yes	11 (78.6%)	3 (21.4%)	1.73	0.52
	No	38 (86.4%)	6 (13.6%)		
CBC abnormality	Yes	9 (75%)	3 (25%)	0.62	0.61
	No	40(86.9%)	6 (13%)		
LFT abnormality	Yes	7(63.6%)	4 (36.4%)	0.59	0.68
	No	42 (89.4%)	5 (10.6%)		
ABG, pH <7.2	Yes	1 (14.3%)	6 (85.7%)	96	<0.001
	No	48 (94.1%)	3 (5.9%)		
HCO_3 <10 mEq/L	Yes	5 (38.5%)	8 (61.5%)	70.4	<0.001
	No	44 (97.8%)	1 (2.2%)		

OR: Odds ratio, GCS: Glasgow Coma scale, ECG: Electrocardiogram, CBC: Complete blood count, ABG: Arterial blood gas, LFT: Liver function tests, HCO_3: Serum bicarbonates

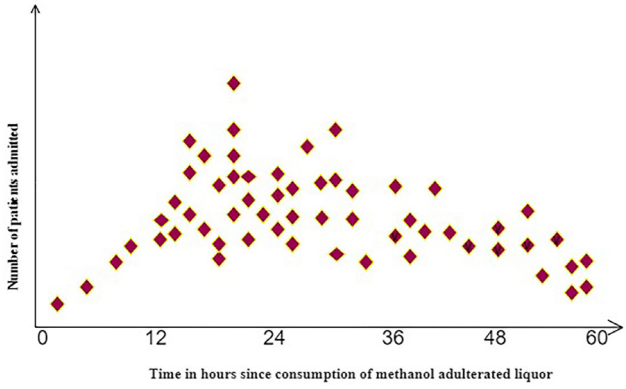

Figure 1. Patients' admission to hospital plotted against time since consumption of methanol adulterated liquor

The outbreak and its aftermath taught us many lessons and posed many questions. Ethanol intravenous preparations are not readily available, and their pharmacokinetics are erratic, with a risk of liver injury and hypoglycemia (13). Despite available resources for ethanol therapy, our patient population could not be motivated to accept it. Patients' and caregivers' reluctance to consent to ethanol treatment was rooted in social taboos and ill-founded misconceptions about further alcohol intake. The apprehension created by social and mass media, fueled the rejection of ethanol therapy. Fomepizole, on the other hand, was unattainable due to non-availability at regional pharmaceutical stores and financial and time constraints. Seven out of nine deaths occurred within 48 hours

of consumption, giving the administration hardly any time to mobilize fomepizole resources from nearby districts. Given this scenario, we were dependent on intensive monitoring and hemodialysis as the only means to salvage the situation. A review after the crisis period revealed salvage options like emergency purchase and expedited couriers from the nearest supply station/stockist, which could have averted delayed deaths.

The silver lining, however, was good triage and instantaneous support from the hemodialysis unit, which helped save lives. Sixteen patients underwent intermittent hemodialysis, among whom 3 died. The impact of hemodialysis in reducing mortality was not significant (p=0.08). Previous research work ascertains that hemodialysis never takes precedence in methanol poisoning in this era of ALD inhibitors, namely fomepizole and ethanol [3,10,11]. Nevertheless, it is an important salvage measure for patients with severe acidosis, acute kidney injury, and life-threatening dyselectrolytemias [6,10]. Chung et al. [14], in their case series, reported the non-disease-modifying effect of hemodialysis in methanol poisoning. In our experience, instituting intermittent hemodialysis, too, did not make a statistically significant difference in the outcome.

The mortality rate varies among developed and developing countries. In India, the experience from 2 tertiary centers documented a death rate between 7.5% and 10% [4,12]. Mortality at our institute fell beyond this range due to many reasons, foremost among them being the care team's limited experience and resource constraints. This was compounded by case flooding, rapid deterioration, ventilator shortage, and non-availability of fomepizole. According to previously published literature, a pH less than 7.22 was a specific predictor of mortality [15]. Another study identified depressed mentation and pH <7.00 to be associated with mortality [16]. The predictors of mortality in our series were depressed mentation, shock, and severe acidosis (pH: <7.2). Our findings mirror similar observations worldwide and thereby reiterate the importance of bedside clinical and point-of-care laboratory markers of prognosis [17].

In the future, the threat of such outbreaks looms large, possibly with more devastating consequences. Our only hope lies in pre-emptive readiness and standard institutional protocol. Though a meticulously structured protocol for such crises depends upon resources, expertise, and strategic location, we do have compelling evidence to recommend certain key elements in patient care. These are most applicable to semi-urban and rural tertiary care centers with limited resources.

1. Gastric decontamination is not effective in methanol poisoning because of rapid absorption [18]. Symptoms develop after a lag period of a few hours, thereby rendering activated charcoal ineffective. Moreover, methyl alcohol as such has limited binding capacity to charcoal [18].

2. Anticipation and activation of health care resources should be accomplished within a time frame of 12 hours from the presentation of the first few cases. A reliable estimation of the anticipated number of patients and peak hospitalization rate can be made with the help of public health authorities. In our series, 89.23% (58/65) of people who consumed the adulterated liquor developed symptoms. Among them, 86.21% were admitted within 48 hours, with admission rates peaking between 12 and 24 hours after consumption. 78% of deaths occurred within 48 hours.

3. Clinical triage tools include assessment of mental status, vital signs, and respiratory distress assessment by pulse oximetry and/or ABG analysis. In our series, we documented worse outcomes with depressed mentation (mortality 53.33%), shock (mortality 66.7%), and hyperpnea (mortality 55.56%).

4. A strong recommendation for ABG as the laboratory triage tool is made here. Serum formic acid level is an ideal investigation that might not be feasible in rural health centers.

5. Lastly, a minimum stock of fomepizole with adequate shelf life needs to be maintained at every such center. Lessons learnt the hard way taught us that ethanol might not be culturally acceptable to our patients/families in light of illiteracy and oversensitive media.

Study Limitations

The study has several limitations, most striking of which are its limited sample size and retrospective nature. Since patients were admitted at a wide range of time periods (6-60 hours) after consumption of adulterated liquor, data collection bias could not be avoided. Panic reactions in the affected population led to many unwarranted admissions, thereby diluting the specificity of clinical manifestations. Secondly, among patients presenting late with altered mentation and/or hemodynamic instability, early features of toxicity could not be reliably documented. Thirdly, a sizeable proportion of patients were referred from nearby primary care centers after initial stabilization. The effect of early resuscitation probably modified the clinical picture of these patients, which could not be ascertained due to the retrospective nature of the study. Fourthly, the mortality-reducing effect of fomepizole is proven beyond doubt in previous research studies [10,11,13]. Fomepizole was not used in our patients for the reasons mentioned above. As expected, we faced an inflated case fatality rate of 15.51%, well beyond the average in two previous outbreaks in India [4,12]. Therefore, in the absence of disease-modifying antidotes, the clinical and laboratory predictors of death lose their strength.

Conclusion

Methanol poisoning outbreaks will continue to occur for more reasons than one. Peak admission rates are to be anticipated at 12-24 hours post-consumption. Standard operating procedures need to be in place at all tertiary treatment centers duly overseen by public health authorities. Baseline triage tools include pH, mental status assessment, and hemodynamic instability. Every tertiary care hospital should maintain emergency reserves of fomepizole perennially and initiate treatment early in such cases based on pH <7.2, serum bicarbonates <10 mEq/L, and depressed mentation.

Ethics

Ethics Committee Approval: The study was approved by the Government Villupuram Medical College and Hospital Institutional Ethics Committee (approval number: GVMC/IEC/2023(2)/3, date: 12.12.2023).

Informed Consent: Retrospective study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: S.K., S.G., J.A., V.P.; Concept: S.K., S.G., Design: S.K., S.G., V.P.; Data Collection or Processing: J.A., V.P.; Analysis or Interpretation: J.A., V.P.; Literature Search: S.K., S.G., J.A.; Writing: S.K., J.A., V.P.

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ORIGINAL RESEARCH

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Comparison of Chest Trauma Score, Revised Trauma Score, and Glasgow Coma Scale in Patients Visiting with Chest Trauma at the Emergency Department

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Abstract

Objective: Thoracic trauma is a significant cause of morbidity and mortality. Accurate assessment of trauma severity is essential for guiding treatment and predicting patient outcomes. This study aims to evaluate the comparative utility of the Glasgow coma scale (GCS), revised trauma score (RTS), and chest trauma score (CTS) to determine the most reliable tool for clinical decision-making in thoracic trauma cases.

Materials and Methods: This prospective, observational cohort study was conducted at a level 1 trauma center between January and June 2015. A total of 110 patients presenting to the emergency department with thoracic trauma were included. Vital signs, trauma scores (GCS, RTS, and CTS), and clinical outcomes were recorded. Primary outcomes included the need for intubation, presence of pneumothorax, and discharge status. Statistical analyses included correlation tests and receiver operating characteristic curve analysis to assess the predictive power of trauma scores.

Results: The patients included in the study were 67.3% male and the mean age was 50.42 years. Patients requiring intubation had significantly lower GCS and RTS scores and higher CTS scores ($p<0.001$). CTS was significantly higher in patients with pneumothorax ($p=0.007$). A strong positive correlation was found between GCS and RTS ($r=0.853$, $p<0.001$), while CTS showed a low negative correlation with both scores ($r=-0.283$, $p=0.003$). CTS showed superior discriminatory power in predicting hospitalization (area under the curve:0.800).

Conclusion: GCS and head revised trauma score are more reliable for assessing overall trauma severity, whereas CTS is more effective in evaluating the severity of chest trauma. A combined approach utilizing all three scores may enhance risk stratification and improve clinical outcomes in patients with thoracic trauma.

Keywords: Chest trauma score, revised trauma score, Glasgow coma scale, thoracic trauma

Introduction

Thoracic trauma is a significant cause of morbidity and mortality, often resulting from mechanisms such as blunt force, penetrating injuries, or motor vehicle accidents. The timely and accurate assessment of patients with chest injuries is crucial for improving clinical outcomes. In the emergency department, various scoring systems are utilized to evaluate trauma severity, guide treatment decisions, and predict patient prognosis [1,2]. Among these, the chest trauma score (CTS), the revised trauma score (RTS), and the Glasgow coma scale (GCS) are widely used to assess different aspects of trauma severity [3-5].

Developed by Teasdale and Jennett [5] in 1974, the GCS is the most commonly used scoring system worldwide for evaluating the level of consciousness in patients with head trauma. The scale comprises three components: eye opening, verbal response, and motor response, with scores ranging from 3 to 15. Lower

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scores indicate a deterioration in the level of consciousness. The RTS is a broader tool that assesses trauma patients based on physiological parameters such as respiratory rate (RR), systolic blood pressure (SBP), and GCS [4]. The CTS, specifically designed to evaluate the severity of chest injuries, considers factors such as rib fractures and pulmonary contusions [3].

The aim of this study is to analyze the concordance of GCS, RTS, and CTS in predicting the prognosis of patients presenting to the emergency department with thoracic trauma. By comparing these trauma scoring systems, the study seeks to identify the most reliable tool for clinical decision-making in the management of thoracic trauma cases.

Materials and Methods

Study Setting and Design

This prospective, observational cohort study was conducted in the Department of Emergency Medicine, Göztepe Prof. Dr. Süleyman Yalçın City Hospital, a level 1 trauma center that serves approximately 300,000 patients annually, including 30,000 trauma cases. The study was carried out using a consecutive sampling of patients presenting with thoracic trauma between January 1, 2015, and June 30, 2015.

Patient Selection and Inclusion/Exclusion Criteria

The study population consisted of all patients who were triaged to the red zone for acute care and received trauma management upon admission. The inclusion criteria were as follows:

- Vital signs and trauma score components were recorded within 30 minutes of admission.
- Patients aged 18 years or older
- Patients who were assigned a red-zone triage code and underwent examination and follow-up in this area
- First-time presentation for the same trauma complaint.

Patients who initially consented but later withdrew their consent were excluded from the study sample.

Data Collection and Applied Protocol

As part of the study, trauma management was performed according to the advanced trauma life support guidelines by emergency medicine specialists and resident physicians at the time of initial presentation [6]. During this process, key parameters such as temperature, pulse, RR, peripheral oxygen saturation (SO_2), SBP, diastolic blood pressure (DBP), GCS, CTS, and RTS were recorded. Additionally, the clinical team noted the trauma mechanism.

All measurements and recordings were conducted using a standardized form. Subsequently, the study investigators supplemented the records with additional clinical information. The clinical course of the patients (discharge, hospitalization, mortality), the department or intensive care unit (ICU), to which they were admitted (if applicable), and the need for surgical intervention were retrieved from the hospital's electronic medical records system.

The collected data were transferred into a specially developed electronic calculation software, which automatically computed the patients' GCS, RTS, and CTS scores using the relevant formulas and calculation methods. To minimize bias, these calculations were conducted in a blinded manner, ensuring that patient data remained inaccessible to the study investigators and researchers.

Statistical Analysis

Continuous variables were expressed as mean, standard deviation, and 95% confidence interval (CI), while categorical variables were reported as frequency and percentage. For variables with less than 10% missing data, acute physiology and chronic health evaluation II (APS II) predictive modeling was applied assuming a normal distribution to complete the missing values. Depending on the distribution of continuous variables, comparisons between two groups were made using either the t-test or the Wilcoxon rank-sum test. Statistical significance was assessed using an independent samples t-test. Levene's test was performed to check for homogeneity of variances, and the p-value was calculated depending on whether variances were equal or unequal. The correlation analysis for continuous variables was conducted using Pearson's method. Receiver operating characteristic (ROC) curves were generated using SPSS v20 (IBM, USA) and MedCalc (MedCalc Software version 10.4.0.0; MedCalc, Mariakerke, Belgium), plotting sensitivity (true positive rate) against the false positive rate (1 -specificity). The area under the curve (AUC) was calculated for each decision criterion. The standard error of the ROC curves and p-values was compared using the method described by Hanley and McNeil. For all analyses, a p-value of <0.05 was considered statistically significant.

Trauma Scoring Systems

Glasgow Coma Scale

Developed by Jennett and Teasdale in 1974, the GCS is widely used to assess the level of consciousness in patients with head trauma. The scale consists of three parameters: eye opening, verbal response, and motor response. The total score ranges from 3 to 15, with lower scores indicating a deterioration in the patient's level of consciousness [5].

Revised Trauma Score

Introduced in the early 1980s, the RTS incorporates three specific physiological parameters: GCS, SBP, and RR. It is recommended for use at the scene of injury or upon the patient's initial evaluation in the emergency department.

In its triage form, each parameter is assigned a score between 0 and 4, resulting in a total score between 0 and 12. In the calculated form, weighting coefficients are applied to each parameter, yielding the RTS value (ranging from 0 to 7.8408) [4].

Head revised trauma score (hRTS)=0.9368×GCS score+0.7326×SBP score+0.2908×RR

Chest Trauma Score

The CTS is calculated based on age, the presence of pulmonary contusion, and rib fractures. It quantifies trauma severity on a scale ranging from 2 to 12. The assigned scores, determined according to age groups, pulmonary contusions, and rib fractures, serve as an additional parameter in the clinical assessment of patients [3].

Ethical Approval

The study was approved by the Göztepe Prof. Dr. Süleyman Yalçın City Hospital Ethics Committee on April 21, 2015. Patient confidentiality was strictly maintained, and the study was conducted in accordance with the Declaration of Helsinki (approval number: 2015/0029, date: 21.04.2015). Written informed consent was obtained from all patients.

Results

A total of 110 patients who visited our emergency department between January 2015 and June 2015 and met the study inclusion criteria were enrolled. Among the participants, 36 (32.7%) were female and 74 (67.3%) were male, with a statistically significant predominance of male patients (one-sample binomial test, p<0.001). A total of 32.7% (n=36) of the patients arrived at the emergency department via ambulance. The majority of patients (81.8%, n=90) had no history of comorbidities (Table 1).

In the study population, 11 patients (10.09%) developed pneumothorax. Among them, 3 patients (2.7%) underwent tube thoracostomy. Of the patients managed and treated in the emergency department, 83.6% (n=92) were discharged, while 5 patients (4.5%) were admitted to the ICU. The number of patients requiring intubation was 4 (3.6%), and 1 patient (0.9%) was recorded as deceased (Table 1).

The mean age of the patients was 50.42±20.46 years, with a median age of 49.5 years. The mean systolic and DBPs were 114.50±15.16 mmHg and 71.52±9.93 mmHg, respectively. The mean pulse rate was 79.05±13.15 beats per minute, the RR was 15.68±3.16 breaths per minute, and the body temperature was 36.55±0.20°C. The mean blood glucose level was 108.67±24.28 mg/dL, and the mean SO_2 was 97.45±2.16% (Table 2).

The study compared trauma scores based on the presence of pneumothorax, intubation requirement, and discharge status. While there was no significant difference in GCS and RTS scores between patients with and without pneumothorax (p>0.05), CTS was significantly higher in patients with pneumothorax (median: 5.00; 25th-75th percentile: 2.00-7.00; p=0.007). Patients requiring intubation had significantly lower GCS (median: 4.00; 25th-75th percentile: 3.00-8.00), hRTS (median: 4.05; 25th-75th percentile: 3.54-5.13), and CTS (median: 6.00; 25th-75th percentile: 5.00-9.50) compared to those who did not require intubation (p=0.000, p=0.000, p=0.001, respectively). When comparing discharged and non-discharged patients, non-discharged patients had lower GCS scores (median: 15.00, interquartile range (IQR): 12.00-15.00), lower hRTS

Table 1. Gender distribution and frequencies of patients

Variable	Category	n (%)
Gender	Female	36 (32.7)
	Male	74 (67.3)
Mode of arrival	By ambulance	36 (32.7)
	By own means	74 (67.3)
Chronic disease	None	90 (81.8)
	Hypertension	13 (11.8)
	Diabetes mellitus	3 (2.7)
	Dementia	2 (1.8)
	Nephrotic syndrome	1 (0.9)
	Depression	1 (0.9)
Tube thoracostomy	Yes	3 (2.7)
	No	107 (97.3)
Endotracheal intubation	Yes	4 (3.6)
	No	106 (96.4)
Pneumothorax	Present	11 (10.0)
	Absent	99 (90.0)
Disposition	Discharged	92 (83.6)
	ICU admission	5 (4.5)
	Ward admission	12 (10.9)
	Deceased	1 (0.9)

ICU: Intensive care unit

Table 2. Age and vital signs of patients

Parameter	Mean ± SD	Median (25th-75th percentile)
Age	50.42±20.46	49.5 (32.0-64.0)
Systolic BP (mmHg)	114.50±15.16	110.0 (110.0-120.0)
Diastolic BP (mmHg)	71.52±9.93	70.0 (67.0-80.0)
Heart rate (bpm)	79.05±13.15	76.0 (72.0-85.0)
Respiratory rate (breaths/min)	15.68±3.16	14.0 (14.0-17.0)
Temperature (°C)	36.55±0.20	36.6 (36.5-36.7)
Blood glucose (mg/dL)	108.67±24.28	102.0 (97.0-112.0)
SpO_2 (%)	97.45±2.16	98.0 (97.0-98.0)

SD: Standard deviation, min: Minimum, BP: Blood pressure, SpO_2: Peripheral capillary oxygen saturation

scores (median: 7.84, IQR: 6.90-7.84), and higher CTS scores (median: 4.50, IQR: 2.00-6.00) (p=0.000, p=0.000, p=0.004, respectively). These findings indicate significant relationships between trauma scores and pneumothorax development, intubation requirement, and discharge status (Table 3).

The correlation between trauma scores and ED discharge status was assessed using Spearman's rho test. The analysis revealed a strong positive correlation between GCS and RTS (r=0.853, p<0.001). A moderate negative correlation was observed between CTS and GCS (r=-0.337, p<0.001), and a significant negative correlation was also found between CTS and hRTS (r=-0.283, p=0.003). These results suggest that GCS and RTS exhibit similar trends, whereas CTS demonstrates an inverse relationship with these scores (Table 4).

The CTS score demonstrated the highest discriminative power with an AUC of 0.800 (95% CI: 0.713-0.871), whereas the GCS and RTS scores had AUC values of 0.633 (95% CI: 0.536-0.723) and 0.655 (95% CI: 0.559-0.743), respectively. Based on the highest Youden index (J), a cut-off value of ≤3 was determined for the CTS score, yielding a sensitivity of 72.6% and a specificity of 80.0% (Figure 1).

Discussion

In our country, approximately 130 million emergency visits occur annually, with around 1,600 emergency thoracic surgeries performed each year [7,8]. The timely and accurate assessment of patients with chest trauma is crucial for improving clinical outcomes. In the emergency department, various scoring systems are utilized to determine trauma severity, guide treatment decisions, and predict patient prognosis [3-5]. This study aimed to evaluate trauma severity using GCS, RTS, and CTS in patients presenting with thoracic trauma and to analyze the correlation between these scoring systems.

In our study, the comparison of trauma scores based on discharge status revealed a strong positive correlation between

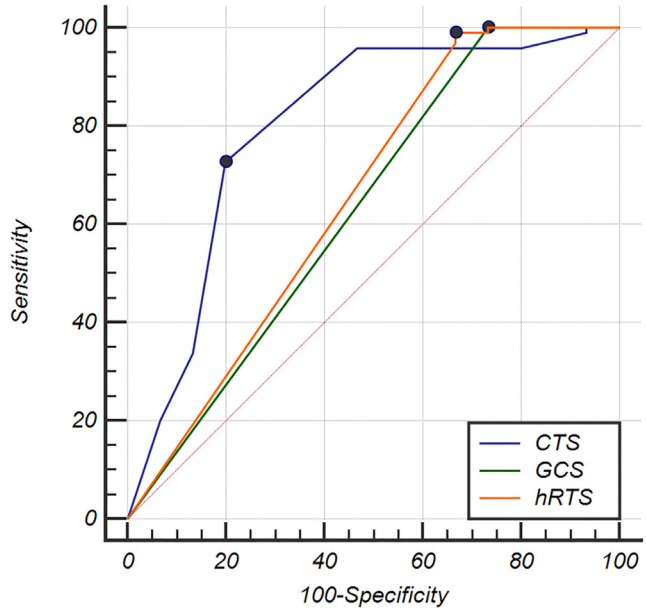

Figure 1. Area under the curve analysis of the CTS, RTS, and GCS for predicting hospitalization in patients with thoracic trauma

CTS: Chest trauma score, GCS: Glasgow coma scale, RTS: Revised trauma score

Table 3. Distribution of severity scores according to pneumothorax, intubation, and emergency department outcomes

Condition	Subgroup	GCS median (IQR)	RTS median (IQR)	CTS median (IQR)	p-value
Pneumothorax	Present (n=11)	15.0 (15.0-15.0)	7.84 (7.84-7.84)	5.0 (2.0-7.0)	0.057
	Absent (n=99)	15.0 (15.0-15.0)	7.84 (7.84-7.84)	3.0 (2.0-4.0)	0.007
Intubation	Yes (n=4)	4.0 (3.0-8.0)	4.05 (3.54-5.13)	6.0 (5.0-9.5)	<0.001
	No (n=106)	15.0 (15.0-15.0)	7.84 (7.84-7.84)	3.0 (2.0-4.0)	0.001
Emergency department outcome	Discharged (n=92)	15.0 (15.0-15.0)	7.84 (7.84-7.84)	3.0 (2.0-4.0)	<0.001
	Hospitalized (n=18)	15.0 (12.0-15.0)	7.84 (6.90-7.84)	4.5 (2.0-6.0)	0.004

IQR: Interquartile range, GCS: Glasgow coma scale, RTS: Revised trauma score, CTS: Chest trauma score

Table 4. Correlation of trauma scores with emergency department discharge

Scores	SD	GCS	hRTS	CTS
GCS	Correlation coefficient	1.000	0.853	-0.337
	p*	.	<0.001	<0.001
RTS	Correlation coefficient	0.853	1.000	-0.283
	p*	<0.001	.	0.003
CTS	Correlation coefficient	-0.337	-0.283	1.000
	p*	<0.001	0.003	.

*Spearman's rho test.

SD: Standard deviation, CTS: Chest trauma score, GCS: Glasgow Coma Scale, RTS: Revised trauma score, hRTS: Head revised trauma score

GCS and RTS (r=0.853, p<0.001). This finding aligns with the reliability of GCS in assessing consciousness levels and the RTS's ability to integrate physiological parameters such as RR, SBP, and GCS score, thereby reflecting the overall trauma severity. Similarly, literature reports indicate that hRTS is particularly effective in predicting prognosis in critically ill patients [4,9]. The negative correlation between CTS and other scoring systems (GCS: r=-0.337, p<0.001; hRTS: r=-0.283, p=0.003) is because CTS evaluates thoracic trauma severity based on different parameters. Specifically, CTS incorporates factors such as age, pulmonary contusion, and rib fractures, making it a chest trauma-specific score that functions independently from other general trauma scoring systems [3,10].

In our study, CTS values were significantly higher in patients who developed pneumothorax (p=0.007), whereas no significant difference was observed in GCS and RTS scores. This finding suggests that CTS better reflects the severity of specific chest injuries such as pneumothorax [3,11]. The findings obtained in this study align with the existing literature regarding the relationship between chest trauma scoring systems and clinical outcomes [3,12]. Specifically, we observed that patients with higher CTSs had a greater need for intubation and a higher incidence of pneumothorax. Similarly, a study by Pressley et al. [13] demonstrated that higher CTS values were associated with an increased likelihood of pulmonary complications and intubation. Additionally, Chen et al. [3] reported that patients with a CTS score of ≥5 had a significantly higher risk of developing pneumonia and requiring mechanical ventilation. These findings are consistent with our study's results regarding the role of CTS in predicting respiratory complications.

Similarly, in patients requiring intubation, GCS, RTS, and CTS values were significantly different (p=0.000, p=0.000, p=0.001, respectively). In particular, lower GCS and RTS scores indicate a deterioration in clinical condition. Given that intubation necessity is directly related to a patient's level of consciousness and respiratory capacity, it can be inferred that GCS and hRTS are more sensitive in determining the need for intubation [5,6].

In the analysis based on discharge status, non-discharged patients had lower GCS and hRTS scores but higher CTS scores (p=0.000, p=0.000, p=0.004). These findings suggest that higher CTS values in patients with severe chest trauma are associated with an increased need for hospitalization. On the other hand, lower GCS and RTS values are linked to greater systemic trauma severity and are considered important indicators of mortality risk [14,15].

The results of our study indicate that trauma scoring systems can be utilized in different clinical domains for patients with chest trauma. While GCS and RTS appear to be more suitable for the general assessment of systemic trauma and prognosis prediction, CTS may be more effective in specifically evaluating the severity of chest trauma. In this context, adopting a combined scoring approach in the management of chest trauma patients may enable a more accurate risk stratification, ultimately leading to improved patient outcomes.

In this study, the CTS score demonstrated superior discriminative power in predicting hospital admission in patients with thoracic trauma compared to the GCS and RTS scores. These findings suggest that the CTS score is a more reliable predictor of hospital admission, effectively identifying patients requiring hospitalization while minimizing unnecessary admissions. Its ability to balance sensitivity and specificity highlights its potential utility in clinical decision-making, ensuring both timely identification of at-risk patients and optimal resource allocation. Future research should explore the prognostic value of the CTS score beyond hospital admission, particularly its association with mortality and clinical outcomes. Additionally, its performance across different trauma mechanisms warrants further investigation. Exploring whether the CTS score can enhance predictive accuracy when combined with existing scoring systems, such as GCS and RTS, may further refine risk stratification strategies in emergency trauma care.

The most significant strength of this study is its direct comparison of different scoring systems in patients with chest trauma, allowing for an evaluation of each system's relationship with clinical outcomes within the same cohort. While most studies in the literature focus on the validation or prognostic value of a single scoring system, our study simultaneously analyzed CTS, RTS, and GCS, providing a comparative perspective. Additionally, the sequential inclusion of patients presenting to the emergency department ensures that the study reflects real-world data, which helps minimize selection bias. Another methodological strength is that all scoring data were obtained from the initial assessment within the same time frame, enhancing consistency between scores. Lastly, the alignment of our findings with the existing literature supports the generalizability of our results.

However, this study also has certain limitations. One of the main limitations is that it was conducted in a single center, which may restrict the external validity of the findings. Additionally, the study primarily focused on short-term clinical outcomes, such as hospital admission and ICU requirement, while long-term outcomes, including functional status and quality of life, were not evaluated. Another potential limitation concerns the calculation of CTS, as some of its parameters, such as pulmonary contusion scoring, require a standardized protocol [16]. Although all imaging studies in our research were performed using a consistent protocol, variations in interpretation could have influenced CTS calculations. Furthermore, commonly used anatomical trauma scores, such as the injury severity score and the abbreviated ınjury scale, were not included in

the analysis, preventing a comparative perspective on overall trauma severity [17,18]. The relatively limited sample size may have also reduced the statistical power of subgroup analyses. For instance, if the number of penetrating chest trauma cases was low, it might have prevented a separate evaluation of the performance of scoring systems within this subgroup.

Study Limitations

Despite these limitations, our study provides a meaningful contribution to the literature. Given the limited number of studies in Türkiye that evaluate chest trauma scoring systems collectively, our findings offer valuable insights for both clinicians and researchers. To address these limitations and strengthen the evidence base, we believe that future studies with larger sample sizes and prospective designs should be planned.

Conclusion

In patients presenting to the emergency department with chest trauma, GCS, RTS, and CTS are scoring systems that assess different clinical conditions while maintaining interrelated characteristics. While GCS and RTS appear to be more reliable in determining overall trauma severity, CTS more accurately reflects the severity of chest trauma. Therefore, utilizing these scores collectively in emergency settings may provide a more comprehensive assessment, ultimately enhancing patient management.

Ethics

Ethics Committee Approval: The study was approved by the Göztepe Prof. Dr. Süleyman Yalçın City Hospital Ethics Committee on April 21, 2015. Patient confidentiality was strictly maintained, and the study was conducted in accordance with the Declaration of Helsinki (approval number: 2015/0029, date: 21.04.2015).

Informed Consent: Written informed consent was obtained from all patients.

Footnotes

Authorship Contributions

Concept: İ.Y., D.A., Design: İ.Y., D.A., Data Collection or Processing: İ.Y., D.A., Analysis or Interpretation: İ.Y., D.A., Literature Search: İ.Y., D.A., Writing: İ.Y., D.A.

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ORIGINAL RESEARCH

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Evaluation of the Frequency and Results of Tomography Use in Patients Diagnosed with Renal Colic in The Emergency Department

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Abstract

Objective: An increasing trend in the utilization of computed tomography (CT) imaging has been observed worldwide for patients presenting to emergency departments with acute flank pain and suspected urolithiasis, resulting in significant exposure to ionizing radiation. This study aims to investigate the frequency and indications of CT imaging, as well as the findings and factors influencing these outcomes.

Materials and Methods: This is a retrospective, single-center study. Patients who presented to the emergency department with acute-onset flank pain were diagnosed with renal colic and underwent non-contrast CT were included in the study. Symptoms other than flank pain, demographic data, comorbid conditions, vital signs, laboratory results and CT findings. The frequency and indications for CT imaging were analyzed along with the CT results and factors influencing findings.

Results: A total of 232 patients were included in this study. Despite the presence of urolithiasis, CT imaging was performed in 15.9% of the patients, CT was performed due to accompanying abdominal pain with flank pain. In 15% of the cases, no indication for CT imaging could be identified. Across the entire patient group, the rate of detecting abdominal pathologies that could contribute to morbidity aside from urolithiasis was found to be 4.7%, with acute cholecystitis and appendicitis being the most commonly observed pathologies.

Conclusion: Severe flank pain was observed as the most common reason for obtaining CT imaging. A significant portion of patients, however, had no identifiable indication for CT. Avoiding CT imaging may be advisable in young male patients with a known history of stones and hematuria. More up-to-date guidelines are especially needed to reduce unnecessary CT imaging.

Keywords: CT imaging, emergency department, renal colic

Introduction

Urolithiasis refers to the formation of calculi within the urinary tract, encompassing the kidneys, bladder, and urethra. The estimated lifetime prevalence of urinary stones is approximately 12%, with the condition most frequently observed in individuals aged 30 to 60 years. Moreover, it is reported to be three times more prevalent in men than in women [1]. Acute flank pain associated with urolithiasis constitutes a significant reason for emergency department visits, contributing to over one million consultations annually in the United States [2]. Ureteral hyperperistalsis during stone formation frequently manifests as acute flank pain, a symptom that, while common in urolithiasis, is non-specific and may be associated with various other conditions [3]. Additionally, irritation and trauma to the ureter can lead to hematuria. A significant complication of urolithiasis is ureteral obstruction, which can result in hydronephrosis. Imaging modalities are essential for diagnosing urinary calculi, as these stones often exhibit non-specific characteristics. Furthermore, imaging plays a crucial role in evaluating differential diagnoses, identifying complications, and assessing the suitability of potential treatment options [3]. Non-contrast computed tomography (CT) has emerged as the predominant

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initial imaging modality for suspected urolithiasis, owing to its high sensitivity, which ranges from 91% to 100% for urinary stone disease [2]. CT is particularly effective in assessing the degree of obstruction caused by ureteral calculi, as it not only confirms the presence and precise location of the stone but also facilitates the identification of other abdominal pathologies. In contrast, renal ultrasonography is generally not a reliable technique for visualizing ureteral stones, often failing to detect stones smaller than 3 mm [4]. This limitation can result in mismanagement in approximately 20% of patients, as ultrasonography provides insufficient information regarding the size and location of the stones [5]. However, unlike other imaging modalities such as ultrasonography, CT subjects patients to significant levels of ionizing radiation, which may increase the long-term risk of cancer [6]. Estimates suggest that some unnecessary abdominal and pelvic CT scans could contribute to cancer development in the United States [2]. Consequently, there is widespread recognition of the need to minimize unnecessary CT imaging for renal colic symptoms. Specifically, the American College of Emergency Physicians recommends limiting CT examinations of the abdomen and pelvis in young, otherwise healthy emergency department patients (aged <50 years) with a known history of urolithiasis who present with symptoms indicative of uncomplicated renal colic [2]. The objective of this study is to evaluate the frequency and indications for CT scanning, the results of these scans, and the factors influencing the findings in patients diagnosed with renal colic, in the emergency department.

Materials and Methods

Study Design

This retrospective study was conducted in the emergency department of a tertiary hospital located in a provincial center that experiences approximately 380,000 patient visits annually. Approval for the study was granted by the local Ankara Atatürk Sanatorium Training and Research Hospital Scientific Studies Ethics Committee under (decision number: 50, date: 24.04.2024). Our research was designed in accordance with the Standards for Reporting of Diagnostic Accuracy Studies statement [7].

Data Collection

Information was extracted from electronic medical records and patient charts. A retrospective chart review was conducted by two emergency medicine specialists, each possessing a minimum of three years of experience. This review included an analysis of clinical and demographic patient characteristics, as well as the results of CT scans.

Study Population

Between January 1, 2021, and December 31, 2023, patients aged 18 years and older who presented to the Emergency Medicine Clinic with flank pain were diagnosed with renal colic, and underwent non-contrast abdominal CT were included in the study. The inclusion criteria were based on ICD-10 codes (International Statistical Classification of Diseases: N23 and its subcodes, R51) retrieved from the hospital's data system. Patients with a history of trauma, known renal malignancy, or incomplete information were excluded from the study.

Patients' symptoms beyond flank pain such as dysuria, abdominal pain, nausea, vomiting, hematuria, and fever-were documented, along with demographic data, comorbid conditions, vital signs, and laboratory results [such as glucose, blood urea nitrogen (BUN), creatinine, white blood cell counts, and an assessment of erythrocytes, leukocytes, and density in a complete urinalysis]. A body temperature of 37.5 °C or higher was classified as a high fever. The indications for CT imaging were categorized as follows: clinical evidence of an associated urinary tract infection, absence of recent kidney stone history, recurrent or persistent severe flank pain in patients over 50 years of age, CT requested by the relevant specialty, presence of oliguria or anuria, and cases suspected to involve complicated renal colic. Complicated renal colic was defined as the presence of fever at presentation, persistent vomiting requiring repeated antiemetic doses, ongoing pain necessitating multiple doses of narcotic analgesics, and a history of underlying urologic or nephrologic disease [2]. It was noted that patients underwent CT scans based on one or more of the defined indications.

CT images were assessed for the presence of stones, hydronephrosis associated with stones, simple cysts, and masses. Patients were divided into two groups based on their non-contrast urinary CT findings: those with urolithiasis (stone positive group) and those without (stone negative group). Concurrently, other abdominal pathologies that could potentially lead to morbidity in the patient were also evaluated on the CT scans. The analysis encompassed CT indications, findings, final diagnoses, and the discharge or hospitalization status of the patients.

Statistical Analysis

Analysis of study data was performed using the IBM SPSS statistical software. The Kolmogorov Smirnov test was used to investigate whether the distribution of discrete and continuous numerical data follows the normal distribution. Continuous numerical variables were shown as median [interquartile range (IQR)], and categorical variables were shown as the number of cases and percentage. Categorical variables were evaluated with chi-square and Fisher's exact test, and continuous variables were evaluated with Mann-Whitney U test. Results for $p<0.05$ were considered statistically significant.

Results

During the study period, 1,770 patients were diagnosed with renal colic in the emergency department, and urinary CT

was performed in 276 patients (15.6%). Forty-two patients were excluded due to missing data, leaving 232 patients for inclusion in the study. Of these, 69.8% were male, and the median age was 33.2 years [interquartile range (IQR) 22.5]. A total of 88% of the patients had no comorbidities, while 15.9% had a prior history of urolithiasis. Urology consultations were requested for 24.1% of the patients, and 8.6% of those patients were subsequently hospitalized. The demographic data of the patients are presented in Table 1, and the indications for CT and the results are provided in Table 2. The most common indication for CT was severe flank pain. CT was performed for one or more of the predefined indications. Despite a known history of urolithiasis, 15.9% of patients underwent CT. In 7.8% of patients, CT was conducted due to abdominal pain accompanying flank pain. Additionally, 15% of patients underwent CT without a clear indication. The incidence of abdominal pathologies unrelated to urolithiasis that could cause morbidity was 4.7%, with the most common conditions being acute cholecystitis and appendicitis.

A comparison between patient groups with and without stones on CT revealed that the majority of patients with urolithiasis were male. These patients more frequently experienced recurrent or persistent severe flank pain, hematuria, and a positive history of kidney stones ($p=0.009$, $p=0.006$, $p=0.034$, respectively). Upon analysis of laboratory results in patients with urolithiasis detected on CT, higher levels of glucose, BUN, and creatinine were observed, along with an increased presence of erythrocytes in the urinalysis (Table 3), ($p=0.01$, $p=0.009$, $p<0.001$, $p<0.001$ respectively).

Discussion

In this study, which examined the frequency, indications, and outcomes of CT in patients presenting with renal colic in the emergency department, we found that 15.6% of patients with a preliminary diagnosis of renal colic underwent CT. The most common indication for CT was severe flank pain. However, despite the relatively low rate of CT utilization, approximately 15% of patients underwent CT without a clear indication. Additionally, some patients underwent CT despite having a known history of urolithiasis.

In the evaluation of patients presenting to emergency departments with suspected renal colic, CT plays a crucial role due to its high sensitivity for diagnosing urolithiasis, providing detailed information on stone size and location. Additionally, CT is effective in identifying other serious conditions that may mimic renal colic symptoms, such as appendicitis and diverticulitis [8]. However, the widespread use of CT may lead to unnecessary radiation exposure, especially in young patients with recurrent renal colic, potentially increasing long-term health risks. Despite the rising trend in CT utilization, studies have shown no significant changes in hospital admission rates or surgical interventions, suggesting that CT may not influence clinical management in some cases [2,9]. In a retrospective cross-sectional analysis conducted by Westphalen et al. [10] across 50 states in the USA, 3-year intervals (1996-1998, 1999-2001, 2002-2004, 2005-2007), 3,818 patients were identified, and it was reported that the rate of CT utilization steadily increased over time (4%, 18.3%, 30.8%, 42.5%) [10]. In our study, the CT utilization rate over a 2-year period was 15.6%. The relatively low rate of CT usage in our study was attributed to the careful adherence to symptoms and findings detailed in the methodology section for ordering CT, the setting of the study in a teaching hospital, and the high consultation rate between specialty trainees and expert physicians during

Table 1. Demographic data of patients (n=232)

Age, years, median (IQR)	44 (22.5)
Sex, n (%)	
Male	162 (69.8%)
Co-morbidity, n (%)	
No comorbidity	204 (87.9%)
Hypertension	13 (5.6%)
Diabetes mellitus	8 (3.4%)
Cardiac disease	6 (2.6%)
Urological disease	14 (6%)
Urolithiasis	37 (15.9%)
Others	6 (2.6%)
Symptoms, n (%)	
Unilateral flank pain	206 (88.8%)
Dysuria	96 (41.4%)
Abdominal pain	66 (28.4%)
Nausea/vomiting	55 (23.7%)
Hematuria	42 (18.1%)
Fever	14 (6%)
Others	32 (13.7%)
Vital signs, median (IQR)	
Pulse	88 (15)
Systolic	134 (12)
Diastolic	84 (11)
Temperature	36.2 (0.1)
Laboratory, median (IQR)	
Glucose	107 (29)
BUN mg/dL	33 (13)
Creatinine mg/dL	1.03 (0.43)
WBC	11 (4.1
Urine analysis	
Erythrocyte	2 (4)
Leukocyte	3 (51)
Density	1014 (16)
Urology consultation	56 (24.1%)
Hospitalization, n (%)	20 (8.6%)
Hospital stay duration, (days) median (IQR)	2 (3)

IQR: Interquartile range, BUN: Blood urea nitrogen, WBC: White blood cell

imaging requests. However, the occurrence of CT scans without clear indications was thought to be because ultrasounds were only available between 08:00 and 16:00 in our hospital.

Many studies in the literature have identified a significant difference in the prevalence of urolithiasis based on gender. According to the European Association of Urology, calcium-containing stones are more common in men, with a male-to-female ratio of 2.7:1 [11]. It is well-established that testosterone plays a key role in stone formation, which likely explains the higher prevalence of urolithiasis observed in male patients in our study.

Urinary system stones have a recurrence rate of 50% within 10 years [12]. In our study, patients with a history of prior stones were significantly associated with having urolithiasis detected on CT. The presence of hematuria was also statistically significant in patients with urolithiasis. However, it is well-documented that 9-33% of patients with stones may not present with hematuria on urinalysis [13,14]. When a patient's history is consistent with renal colic, the presence of hematuria strongly supports urolithiasis as the most likely diagnosis. Repeated CT scans in patients with a known history of stones may have been prompted by complications such as concomitant infection or by requests from consulting clinics for further evaluation. In the literature, a retrospective study evaluating patients with a known history of urolithiasis, who presented to the emergency department with recurrent symptoms and underwent CT imaging, reported that 82% of the patients were diagnosed with renal colic, with no significant difference compared to their CT findings. Additionally, an alternative non-urgent diagnosis was made in 11.6% of the cases, while 6.5% of the patients were found to have a diagnosis requiring urgent intervention [15].

Table 2. Computed tomography imaging findings

***CT imaging results,** n (%)	
No evidence of calculi	75 (32.3%)
Presence of stone	70 (30.2%)
Stone + presence of hydronephrosis	87 (37.5%)
Simple renal cyst	23 (9.9%)
Pathological conditions associated with potential morbidity	11 (4.7%)
Acute appendicitis	3
Acute cholecystitis	3
Ovarian cyst	2
Acute pancreatitis	2
Renal infarct	1
****Clinical indication for computed tomography**	
Severe pain/recurrent analgesic needs	66 (28.4%)
Suspicion of urinary tract infection more than two vomiting	48 (20.7%) 30 (12.9%)
Hematuria	42 (18.1%)
Oliguria	12 (5.2%)
Presence of urolithiasis history	37 (15.9%)
Abdominal pain with flank pain	18 (7.8%)
After consultation	30 (12.9%)
No indication available	35 (15.1%)

*A patient may have multiple computed tomography findings

**The patient was referred for computed tomography based on several clinical indications

The literature indicates that CT findings can aid in the identification of abdominal pathologies beyond urolithiasis [12,13]. In a study where a diagnosis other than urolithiasis was established in 9% of all CT scans, only 6.1% of these cases were deemed acutely significant. In our study, non-renal abdominal pathologies that could cause morbidity were detected in 11 patients (4.7%). Previous research has shown that incidental pathologies are more frequently identified in women and geriatric patients [16]. However, in our study, the results may differ due to the predominance of male and younger patients, who constituted approximately 70% of our cohort. The most common pathologies detected were acute appendicitis and acute cholecystitis. It is important to note that non-renal abdominal pathologies can present with symptoms and urinary features that mimic those of renal pathologies. A study by Özen Olcay et al. [17] evaluating the urinalysis of patients with acute appendicitis found a considerable incidence of hematuria.

Inadequate water consumption, dehydration, and hyperglycemia are associated with the formation of urinary stones. Chronic hyperglycemia increases urinary calcium excretion and promotes calcium stone formation. Type 2 diabetes is a strong predictor of uric acid stone formation due to lower urine pH and insulin resistance mechanisms [18]. While low fluid intake is a recognized risk factor for stone disease, increasing fluid consumption may contribute to a reduction in the recurrence of stones. Additionally, renal function tests may be adversely affected in dehydrated patients [19, 20]. In our study, elevated levels of glucose, BUN, and creatinine were significantly associated with pathological findings on CT. This relationship may be attributed to dehydration, which can lead to urolithiasis, resulting in the onset of flank pain in patients.

Study Limitations

Finally, the generalizability of our study is limited because of its design as a single-center audit with a relatively small sample size. Additionally, a limitation arises from the possibility that emergency department physicians may have considered the diagnosis of urolithiasis, however, an alternative discharge ICD diagnosis may have been recorded in the hospital's automated system.

Conclusion

Despite current guidelines, CT is frequently utilized as the initial diagnostic modality for suspected recurrent renal colic.

Table 3. Analysis of patient groups with and without stones based on computed tomography findings

Characteristic	Urolithiasis positive (n=157)	Urolithiasis negative (n=75)	p
Sex, n (%) Male	123 (78.3)	39 (52)	<0.001
Age, years, median (IQR[1])	45 (21)	41 (20)	0.139
Co-morbidity, n (%)			
No comorbidity	20 (12.7)	8 (10.7)	0.650
Hypertension	11 (7)	2 (2.7)	0.232
Diabetes mellitus	6 (3.8)	2 (2.7)	1.000
Cardiac disease	5 (3.2)	1 (1.3)	0.667
Urologic disease	9 (5.7)	5 (6.7)	0.774
Indication for computed tomography, n (%)	53 (33.8)	13 (17.3)	0.009
Severe pain/recurrent analgesic suspicion of UTI	64 (40.8)	32 (42.7)	0.783
More than two vomiting	22 (14)	8 (10.7)	0.537
Hematuria	36 (22.9)	6 (14.3)	0.006
Oliguria	10 (6.4)	2 (2.7)	0.346
Presence of urolithiasis history	31 (19.7)	6 (8)	0.034
Abdominal pain with flank pain	15 (9.6)	3 (4)	0.191
Vital signs, median (IQR)			
Pulse	101 (6)	100 (8)	0.433
Systolic	132 (10)	135 (14)	0.215
Diastolic	85 (10)	83 (13.5)	0.802
Temperature	36.6 (0.5)	36.4 (0.3)	0.851
Laboratory, median (IQR)			
Glucose	109 (29)	105.5 (30.3)	0.010
BUN mg/dL	33 (14)	30 (13.5)	0.009
Creatinine mg/dL	1.12 (0.42)	0.92 (0.34)	<0.001
WBC	11.1 (5.13)	10.5 (4.53)	0.220
Urine analysis			
Erythrocyte	7 (80)	1 (5)	<0.001
Leukocyte	2 (4.5)	2 (4)	0.371
Density	1015 (17)	1010 (16)	0.114
Hospitalization, n (%)	16 (10.2)	4 (5.3)	0.317
Hospital stay duration, (days) median (IQR)	2.5 (3.7)	2 (1.5)	0.962

IQR: Interquartile range. UTI: Urinary tract infection, WBC: White blood cell, BUN: White blood cell

Severe flank pain was identified as the most common indication for CT. Notably, a substantial proportion of patients underwent CT scans without a clear indication. It may be advisable to avoid CT imaging in young male patients with a known history of urolithiasis and hematuria. There is a pressing need for updated guidelines to minimize unnecessary CT imaging, particularly in this patient population.

Ethics

Ethics Committee Approval: Approval for the study was granted by the University of Health Sciences Türkiye, Ankara Atatürk Sanatorium Training and Research Hospital Scientific Studies Ethics Committee under (decision number: 50, date: 24.04.2024).

Informed Consent: Retrospective study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: Y.Y.A., E.E., Z.H.T., Y.Ç., Concept: Y.Y.A., E.E., H.Ö.O., Z.H.T., Y.Ç., Design: Y.Y.A., E.E., H.Ö.O., Z.H.T., Y.Ç., Data Collection or Processing: Y.Y.A., E.E., Z.H.T., Analysis or Interpretation: Y.Y.A., E.E., H.Ö.O., Y.Ç., Literature Search: Y.Y.A., E.E., H.Ö.O., Z.H.T., Writing: Y.Y.A., E.E., Y.Ç.

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ORIGINAL RESEARCH

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Evaluation of Performance and Complications in Freediving Competitions by Gender, Discipline, and Competition Type

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Abstract

Objective: Freediving is a unique underwater sport that relies on voluntary breath-hold, with competitions held in multiple disciplines such as constant weight diving (CWT), free immersion diving (FIM), constant weight no fins (CNF), and bifins (BF). Performance depends on physiological, psychological, and environmental factors, while complications such as hypoxic blackout (BO) and disqualification (DQ) represent significant safety concerns. This study aimed to evaluate freediving competition outcomes in Türkiye by gender, discipline, and competition type, with a focus on performance parameters and complications.

Materials and Methods: A retrospective descriptive analysis was conducted using official records of national and international freediving competitions organized by the Turkish Underwater Sports Federation (TSSF) in 2021. Data from 150 athletes (57 women, 38%; 93 men, 62%) were included. Performance metrics (target distance, achieved distance, final distance, penalty distance, target/performance and final/target ratios) and complications (BO, DQ, did not start [DNS], non-participation) were analyzed. Statistical evaluations were performed with NCSS 2020, using t-tests, Mann–Whitney U, Kruskal–Wallis, and Dunn tests where appropriate, with $p<0.05$ considered significant.

Results: Among women, 74% completed their events, while 26% were eliminated, mostly due to DNS (35%) and non-participation (30%). Among men, 83% completed competitions, while 17% were eliminated, with BO being the most frequent cause (31.6%). In international competitions, male athletes achieved significantly greater target, performance, and final distances in the CWT and FIM disciplines compared to national competitions ($p<0.05$). Female athletes showed no significant differences across competition levels.

Conclusion: Male athletes demonstrated higher overall performance, while female athletes had higher DNS and non-participation rates, suggesting the influence of motivational and psychological factors beyond physiology. BO emerged as the most critical complication, underscoring the need for strict safety protocols and rapid emergency response systems. This study highlights that freediving performance is determined not only by physical capacity but also by discipline selection, competition type, and psychological readiness. Strengthening safety measures and developing prospective, multicenter studies will be essential to optimize performance and reduce risks in future competitions.

Keywords: Apnea competition, athlete safety, blackout, disqualification, freediving, gender differences, performance analysis, underwater sports

Introduction

Freediving is a sport discipline based on performances carried out underwater without the use of any breathing apparatus, relying solely on the athlete's breath-hold. Rooted in the physiology of apnea (breath-holding), this discipline has gained increasing popularity in both recreational and competitive contexts. Freediving competitions are organized in different disciplines such as static apnea (STA), dynamic apnea with fins (DYN), dynamic apnea without fins (DNF), constant weight diving (CWT), free immersion diving (FIM), and constant weight no fins (CNF). Athletes' performances are evaluated based on parameters such as dive duration, distance covered, or depth reached [1–4].

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Globally, freediving has been systematically regulated since the second half of the 20th century, and after the 1990s, it gained an institutional structure under the supervision of international federations such as the Confédération Mondiale des Activités Subaquatiques (CMAS) and the International Association for Development of Apnea (AIDA) [1–4]. In Türkiye, the development of this sport accelerated in the 2000s through competitions organized by the Turkish Underwater Sports Federation (TSSF). With the achievements of national athletes in international championships, the visibility of Türkiye in the field of freediving has increased [5,6].

The physiological foundations of this sport are explained by biological mechanisms such as cardiorespiratory adaptations, hypoxic tolerance, the diving reflex (bradycardia, peripheral vasoconstriction), and lactate accumulation. On the psychological level, mental resilience, anxiety management, and concentration are among the important determinants [7–9]. Therefore, freediving is regarded not only as a sporting activity but also as a multidisciplinary field of research that examines the limits of human physiology and adaptation to environmental stressors.

In recent years, the importance of performance analyses in freediving has increased. Associating athlete performance with biomechanical, physiological, and psychological parameters enables training processes to be based on scientific foundations and competition strategies to be optimized [7–9]. At the same time, identifying complications that may occur during competitions is of critical importance in terms of athlete safety and organizational improvement. In this context, the aim of this study is to analyze the results obtained in freediving competitions held in Türkiye in 2021, to comparatively evaluate performances across different disciplines, and to examine in detail the complications observed during the competition process.

Materials and Methods

Study Design

This research is a retrospective, descriptive analytical study conducted using the official records of freediving competitions held in Türkiye. The study examined the performance data of male and female athletes competing in different disciplines, as well as the reasons for disqualification and complications recorded during the competition process.

Study Population

The research was conducted through a retrospective examination of data from athletes who participated in freediving competitions held in Türkiye in 2021. A total of 189 athletes who took part in national and international freediving competitions organized by the Turkish Underwater Sports Federation (TSSF) were included in the study. Due to incomplete or incorrect data, 39 athletes were excluded from the analysis. Ultimately, the data of 150 athletes (57 women, 38%; 93 men, 62%) were evaluated.

Only participants with complete official result sheets who completed the competitions were included in the study, whereas athletes with insufficient data, those who did not participate, or those who were disqualified were excluded.

Performance Variables

In this study, the performance levels of athletes and the data related to the competition process were considered in a multidimensional manner. The gender of the participants (female/male), competition type (national/international), and discipline types [constant weight no fins (CNF), constant weight diving (CWT), free immersion diving (FIM), and bifins (BF)] constituted the basic demographic and structural variables. In the performance evaluation, target distance, achieved performance distance, and final distance measurements were taken into account. In addition, target/performance percentage and final/target percentage ratios were calculated, and the penalty distances received by the athletes were recorded. Complications and reasons for disqualification during the competition process were also classified; these included blackout (BO), did not start (DNS), disqualification (DQ), and non-participation. In this study, the term "complications" is used as a general expression encompassing both medical adverse events and non-medical competition-related outcomes recorded during the competition process. Medical adverse events include fainting (BO), while non-medical outcomes include failure to start the race (DNS), disqualification (DQ), and non-participation, as documented in official competition records.

Blackout (BO) was defined as a transient loss of consciousness occurring during ascent or immediately after surfacing, as identified and recorded by competition judges and on-site medical staff in accordance with CMAS and AIDA competition regulations.

Statistical Analysis

For the evaluation of the findings obtained in the study, NCSS (Number Cruncher Statistical System) 2020 Statistical Software (NCSS LLC, Kaysville, Utah, USA) was used for statistical analyses. While evaluating the study data, quantitative variables were expressed as mean, standard deviation, median, minimum, and maximum values, and qualitative variables were expressed using descriptive statistical methods such as frequency and percentage. The Shapiro–Wilk test and box plot graphics were used to assess the conformity of the data to normal distribution.

For comparisons of two groups of quantitative variables showing normal distribution, the Student's t-test was applied. For variables not showing normal distribution, the Mann–Whitney U test was used for comparisons of two groups; for comparisons of three or more groups, the Kruskal–Wallis test was used, and the Dunn test was employed to determine the group responsible for the difference. The results were evaluated within a 95% confidence interval, with a significance level of $p<0.05$.

Ethical Considerations

This study was approved by the Non-Interventional Clinical Research Ethics Committee of Erzincan Binali Yıldırım University with the decision dated 09.08.2024 and numbered 378201. The study data were obtained solely from the official and open-access competition records published by the Turkish Underwater Sports Federation (TSSF). The identity information of the participants was kept confidential, and only anonymized data were analyzed. The article is conducted according to the Declaration of Helsinki.

Results

A total of 189 athletes were initially assessed. Following the exclusion of 39 athletes due to elimination or incomplete participation, the final analysis included 150 athletes, comprising 38% women (n=57) and 62% men (n=93).

Participant Characteristics and Elimination Outcomes

Overall, 79.4% of participants successfully completed the competition, while 20.6% were eliminated. Completion rates were higher in men than in women (83.0% vs. 74.0%). Blackout accounted for a greater proportion of eliminations among male athletes, whereas did not start (DNS) was more frequent among female athletes. A detailed summary of completion status and reasons for elimination stratified by gender and competition level is presented in Table 1.

Participation Rates by Discipline and Gender

The distribution of freediving disciplines differed between women and men (Fig. 1). Among women, bifins (BF) was the most frequently competed discipline (38.6%), followed by free immersion (FIM, 29.8%), constant weight with fins (CWT, 17.5%), and constant weight no fins (CNF, 14.0%). In contrast, male participants most commonly competed in free immersion (FIM, 37.6%), followed by constant weight with fins (CWT, 24.7%), bifins (BF, 23.7%), and constant weight no fins (CNF, 14.0%).

Overall Performance by Gender

General performance characteristics stratified by gender are summarized in Table 2. Mean target, performance, and final distances were comparable between women and men. Both sexes demonstrated high achieved/target and final/target percentages, indicating that most athletes reached distances close to their declared targets, with no clinically meaningful difference in performance efficiency between genders.

Comparison Between National and International Competitions

Athletes competing in international competitions achieved significantly greater target, performance, and final distances compared with those participating in national competitions (Fig. 2). Despite these differences in absolute distances, relative

Table 1. Distribution of notes regarding the reasons for elimination of participants

	Women n (%)	Men n (%)	Total n (%)
National – Completed	23 (67.6)	50 (82.0)	73 (76.8)
International – Completed	34 (79.1)	43 (84.3)	77 (81.9)
Total – Completed	57 (74.0)	93 (83.0)	150 (79.4)
Total – Eliminated	20 (26.0)	19 (17.0)	39 (20.6)
Blackout – National	2 (18.2)	2 (18.2)	4 (18.2)
Blackout – International	1 (11.1)	4 (50.0)	5 (29.4)
Blackout – Total	3 (15.0)	6 (31.6)	9 (23.1)
Did Not Start – National	0 (0.0)	0 (0.0)	0 (0.0)
Did Not Start – International	7 (77.8)	2 (25.0)	9 (52.9)
Did Not Start – Total	7 (35.0)	2 (10.5)	9 (23.1)
Disqualification – National	3 (27.3)	1 (9.1)	4 (18.2)
Disqualification – International	1 (11.1)	2 (25.0)	2 (11.8)
Disqualification – Total	4 (20.0)	3 (15.8)	6 (15.4)
Did Not Participate – National	6 (54.5)	8 (72.7)	14 (63.6)
Did Not Participate – International	0 (0.0)	0 (0.0)	0 (0.0)
Did Not Participate – Total	6 (30.0)	8 (42.1)	14 (35.9)

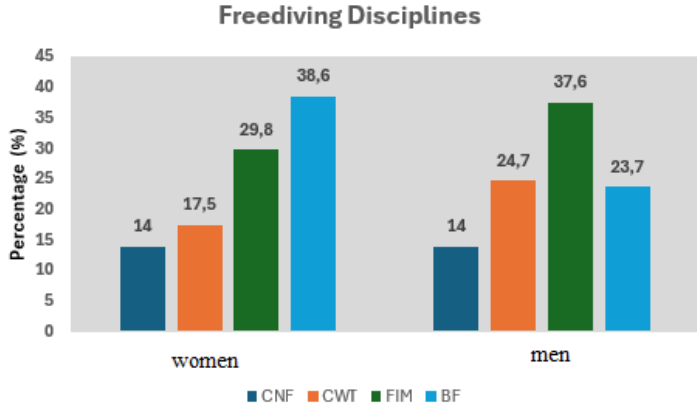

Figure 1. Participation rates in disciplines by gender.

performance efficiency, reflected by achieved/target and final/target percentages, remained similar between competition levels.

Discipline-Based Performance Characteristics

Discipline-specific differences were observed in target, performance, and final distances (Fig. 3). Constant weight with fins (CWT) consistently demonstrated the greatest distances, followed by free immersion (FIM) and bifins (BF), while constant weight no fins (CNF) showed the lowest values across all distance measures.

When discipline-specific comparisons were examined in detail, significant differences between national and international competitions were primarily observed in the CWT discipline among male participants, with higher target, performance, and final distances achieved in international events (Table 3). No significant differences were observed in performance efficiency ratios.

Discussion

In this study, the performance data of athletes and the complications that emerged during competitions organized in Türkiye were examined according to gender, discipline, and competition type. The findings indicate that success and safety in freediving depend not only on physiological capacity but also on psychological preparation, discipline selection, and organizational factors.

Although the completion rates of female and male athletes were similar, the success rate was found to be higher in males. In the literature, it has been reported that male athletes have advantages such as larger lung volumes, greater muscle mass, and higher maximal oxygen consumption, which are positively reflected in performance [10,11].

Some studies suggest that female athletes may exhibit adaptive responses to the diving reflex; for example, in the study by Rey-Paredes et al. [12], women demonstrated a stronger bradycardic response during the first apnea, although this difference diminished in subsequent apneas. In addition, the study by Baranova et al. [13] reported that pulmonary vasodilation responses were more pronounced in women than in men. On the other hand, Pernett et al. [14] observed similar levels of heart rate reduction between women and men.

Thus, it is known that female athletes may also have advantages in hypoxia tolerance and can exhibit adaptive responses to the diving reflex. In our study, the higher rates of DNS (Did Not Start) and non-participation among female athletes suggest that, in addition to physiological differences, motivational and psychological factors may also play a role. Indeed, performance analyses conducted in underwater sports have shown that, particularly among young female athletes, differences in club infrastructure and competitive imbalances can directly influence individual motivation and athlete development processes [15].

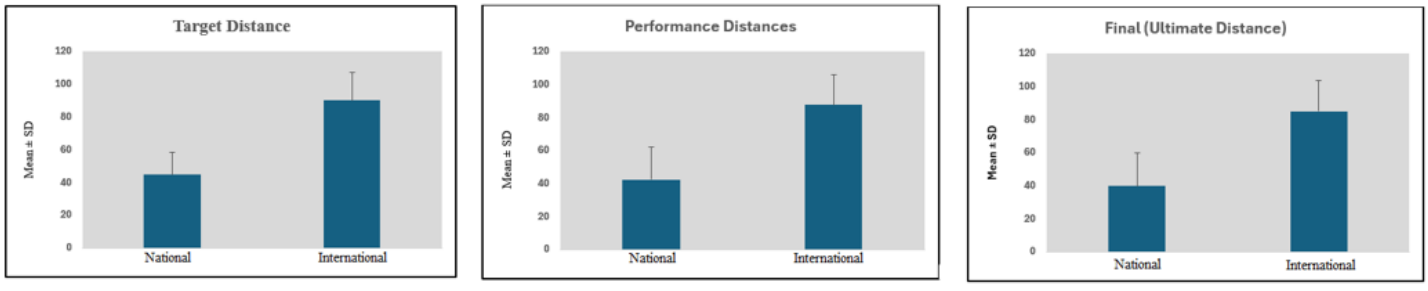

Figure 2. Comparison of target, performance, and final distances between national and international freediving competitions. (A) Target distance, (B) performance distance, and (C) final (ultimate) distance.

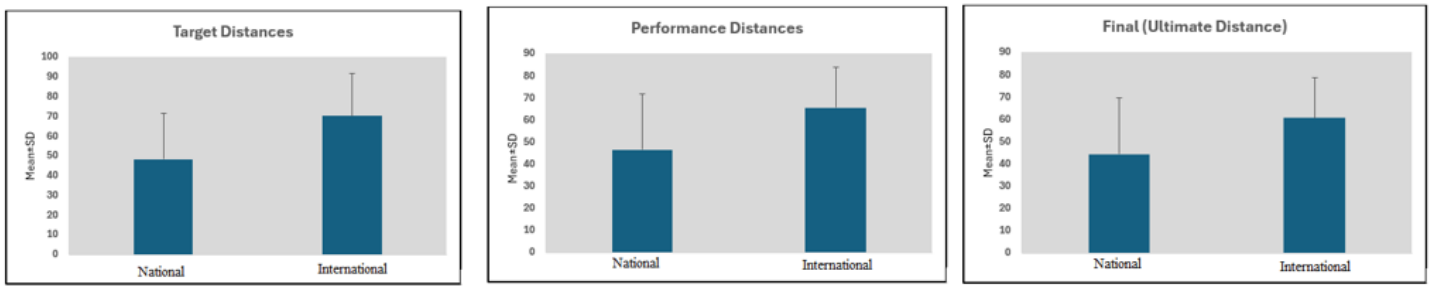

Figure 3. Discipline-based comparison of target, performance, and final distances in freediving. (A) Target distances, (B) performance distances, and (C) final (ultimate) distances across constant weight no fins, constant weight diving, free immersion diving, and bifins disciplines.

Table 2. Performance variables of participants by gender

Variable	Women n (%) / Mean±SD	Men n (%) / Mean±SD
Gender	57 (38.0)	93 (62.0)
Discipline		
Constant weight no fins (CNF)	8 (14.0)	13 (14.0)
Constant weight diving (CWT)	10 (17.5)	23 (24.7)
Free immersion diving (FIM)	17 (29.8)	35 (37.6)
Bifins (BF)	22 (38.6)	22 (23.7)
Target distance (m)		
Mean±SD	57.79±19.21	58.08±23.16
Median (Min–Max)	55 (26–106)	56 (20–109)
Performance distance (m)		
Mean±SD	55.45±20.31	56.01±22.72
Median (Min–Max)	51 (21–106)	55 (14.5–108)
Achieved/Target distance (%)		
Mean±SD	95.20±9.95	96.30±8.34
Median (Min–Max)	100 (52.4–100)	100 (63.1–100)
Final distance (m)		
Mean±SD	52.65±22.29	53.73±23.30
Median (Min–Max)	50 (1.2–106)	53 (7.8–108)
Final/Target (%)		
Mean±SD	89.64±20.69	92.19±17.51
Median (Min–Max)	100 (2.7–100)	100 (24.5–100)
Penalty distance (m)		
Mean±SD	9.22±4.34	10.21±5.29
Median (Min–Max)	8.5 (4.1–21.4)	8.8 (3–21.4)
Achieved/Penalty (%)		
Mean±SD	18.25±11.53	17.19±9.60
Median (Min–Max)	12.8 (6–47.6)	16.9 (2–36.9)

SD: Standard deviation

Table 3. Comparison of relevant measurements by groups in the constant weight diving discipline

Variable	National	International	p
Women	n=5	n=5	
Target distance (m), Mean±SD Median (Min–Max)	57.00±17.73 50 (40–83)	75.40±11.37 78 (57–85)	[a] *0.095*
Performance distance (m), Mean±SD Median (Min–Max)	57.00±17.73 50 (40–83)	73.20±13.12 78 (51–85)	[a] *0.151*
Achieved/Target (%) Mean±SD Median (Min–Max)	100.00±0.00 100 (100–100)	96.7±4.79 100 (89.5–100)	[a] *0.310*
Final distance (m), Mean±SD Median (Min–Max)	54.84±14.05 50 (40–72.2)	70.60±15.66 73 (44–85)	[a] *0,095*
Final/Target (%) Mean±SD Median (Min–Max)	97.40±5.82 100 (87–100)	92.82±10.41 100 (77.2–100)	[a] *0.548*
Penalty distance (m) Mean±SD Median (Min–Max)	4.90±0.00 4.9 (4.9–4.9)	6.50±0.71 6.5 (6–7)	
Achieved/Penalty (%) Mean±SD Median (Min–Max)	0.00±0.00 0 (0–0)	8.24±3.23 8.2 (6–10.5)	–
Men	n=13	n=10	
Target distance (m), Mean±SD Median (Min–Max)	44.62±13.77 35 (30–67)	90.10±16.97 93 (46–108)	[a] 0.001**
Performance distance (m), Mean±SD Median (Min–Max)	42.32±16.29 35 (19.9–67)	87.80±17.02 89.5 (46–108)	[a] 0.001**
Achieved/Target (%) Mean±SD Median (Min–Max)	93.08±13.34 100 (64.2–100)	100 (86.3–100)	
Final distance (m), Mean±SD Median (Min–Max)	39.80±19.83 35 (7.8–67)	85.20±18.34 89.5 (46–108)	[a] 0.001**
Final/Target (%) Mean±SD Median (Min–Max)	85.47±27.98 100 (25.2–100)	94.77±10.09 100 (71.6–100)	[a] 1.000
Penalty distance (m) Mean±SD Median (Min–Max)	9.93±1.32 10.2 (8.5–11.1)	8.67±5.51 9 (3–14)	
Achieved/Penalty (%) Mean±SD Median (Min–Max)	29.98±5.45 29.1 (25–35.8)	8.18±5.88 8.9 (2–13.7)	–

a: Mann–Whitney U test. **p<0.01. Statistical comparisons were not performed for variables with insufficient sample size. SD: Standard deviation

When analyzed by discipline, it was found that male athletes achieved significantly greater distances in the CWT and FIM disciplines in international competitions compared to national ones. This finding suggests that the higher level of competition, preparation processes, and motivational factors in international events may positively influence performance. In female athletes, however, no significant differences were observed between national and international competitions. This may be explained by the relatively smaller number of female participants or the more homogeneous level of experience among them.

When complications were examined, it was observed that blackout (BO), DNS, DQ, and non-participation occurred at notable rates during competitions. BO was more frequent among male athletes, while DNS was more common among female athletes. BO is one of the most critical complications in freediving, as it may result in hypoxic syncope; the risk increases with the rapid decline in alveolar oxygen pressure and the prolongation of apnea duration [16,17]. Mulder et al. [18] reported that progressive changes in oxygenation and the diving response during repeated apneas increased the risk

of hypoxia-induced loss of consciousness. Similarly, Mulder et al. [19] demonstrated that multiple factors in deep dives contribute to an increased risk of hypoxic blackout. Moreover, studies using field measurements have shown that decreases in SpO2 are associated with dive depth and can be used to predict blackout risk [17]. These findings highlight the importance of strengthening safety protocols during competitions and raising athletes' awareness of risks. Particularly in life-threatening complications such as blackout, the implementation of rapid and effective emergency response protocols is of critical importance. In this context, the presence of multidisciplinary medical teams, in which emergency medicine specialists and diving physicians work in coordination, is an essential requirement for ensuring athlete safety. From an emergency medicine perspective, blackout represents an acute and potentially life-threatening event requiring immediate recognition and intervention. Rapid on-site emergency response, continuous monitoring during ascent and recovery, and the presence of trained multidisciplinary medical teams are critical components for preventing fatal outcomes. The involvement of emergency medicine specialists, in coordination with diving physicians, plays a key role in the safe organization and supervision of freediving competitions.

The strength of our study lies in the comparative analysis of a broad dataset across different disciplines, genders, and competition types. However, an important limitation is the retrospective design and the exclusive use of official competition records, which did not allow for the evaluation of individual physiological and psychological variables (e.g., VO2max, anxiety levels, years of experience).

In conclusion, performance in freediving depends not only on the athlete's physiological capacity but also on discipline selection, competition level, motivational factors, and safety strategies. Prospective and multicenter studies in the future are expected to contribute to the prevention of complications and the enhancement of athlete safety.

Conclusion

This study comparatively evaluated performance and complications across different disciplines, genders, and competition types in freediving competitions held in Türkiye. The findings showed that male athletes had higher overall success rates and, particularly in the CWT and FIM disciplines, achieved better performance in international competitions. In female athletes, higher rates of DNS and non-participation may be associated not only with physiological differences but also with motivational and psychological factors. The results highlight that in freediving competitions, not only performance but also the management of complications and emergency response processes are of vital importance.

Among complications, the most critical risk is blackout (BO), and strengthening safety protocols as well as implementing progressive training strategies are essential for athlete safety. Future prospective, multicenter, and physiologically focused studies are expected to contribute to the prevention of complications and the enhancement of athlete safety in freediving.

Study Limitations

This study has certain limitations. First, its retrospective design restricted the ability to control for potential confounding factors. Only official competition records published by the Turkish Underwater Sports Federation (TSSF) were used; thus, detailed individual physiological and psychological variables (e.g., VO2max, anxiety levels, training history) could not be evaluated. In addition, the study was limited to competitions held in Türkiye in 2021, which may reduce the generalizability of the findings to broader international freediving populations. Future prospective, multicenter studies with direct physiological and psychological measurements are needed to provide deeper insights into performance determinants and complication risks in freediving.

Ethics Committee Approval: This study was approved by the Non-Interventional Clinical Research Ethics Committee of Erzincan Binali Yıldırım University (Date: 09.08.2024, Decision no: 378201).

Informed Consent: The study data were obtained solely from the official and open-access competition records published by the Turkish Underwater Sports Federation. The identity information of the participants was kept confidential, and only anonymized data were analyzed.

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Authorship Contributions:

Concept: R.Ö., A.S.Y.K., O.T., S.G.U.; Design: R.Ö., A.S.Y.K., O.T., S.G.U.; Supervision: R.Ö., A.S.Y.K., O.T., S.G.U.; Resource: R.Ö., A.S.Y.K., O.T., S.G.U.; Materials: R.Ö., A.S.Y.K., O.T., S.G.U.; Data collection and/or processing: R.Ö., A.S.Y.K., O.T., S.G.U.; Analysis and/or interpretation: R.Ö., A.S.Y.K., O.T., S.G.U.; Literature review: R.Ö., A.S.Y.K., O.T., S.G.U.; Writing: R.Ö., A.S.Y.K., O.T., S.G.U.; Critical review: R.Ö., A.S.Y.K., O.T., S.G.U.

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ORIGINAL RESEARCH

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Investigation of Viral Serology in Patients Admitted to the Emergency Department with Symptoms of Upper Respiratory Tract Infection Following the COVID-19 Pandemic

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Abstract

Objective: Respiratory tract infections (RTIs) are a significant public health problem, especially during winter, causing increased emergency department (ED) visits and antibiotic prescriptions. Rapid and accurate identification of causative pathogens is crucial for appropriate management and infection control.

Materials and Methods: This prospective, observational, single-center study included 322 adult patients presenting with symptoms of upper respiratory tract infection to a university hospital ED between October 2023 and March 2024. Nasal and oropharyngeal swab samples were collected from all participants and analyzed using multiplex RT-qPCR for 21 respiratory pathogens, including SARS-CoV-2. Demographic data, clinical features, and physicians' initial intentions regarding antibiotic or antiviral prescriptions were recorded.

Results: At least one respiratory pathogen was detected in 68.6% of patients, with Influenza A (17.1%), COVID-19 (11.2%), and Influenza B (6.8%) being the most common. Coinfection with two pathogens was found in 6.2% of cases, most frequently involving Influenza A and RSV. Before receiving PCR results, physicians reported that they would prescribe antibiotics to 32.9% of patients.

Conclusion: These findings highlight the importance of rapid diagnostic testing in reducing unnecessary antibiotic use and provide updated epidemiological data on adult RTIs in the post-COVID-19 era.

Keywords: Antibiotic stewardship, emergency department, multiplex PCR, upper respiratory tract infection, viral pathogens

Introduction

Respiratory tract infections (RTIs) are a major health concern worldwide, especially during winter due to seasonal epidemics [1]. They contribute significantly to morbidity and mortality, as well as increased emergency department (ED) visits and antibiotic prescriptions [1,2]. Respiratory viruses play an important role in the etiology, followed by bacteria [3].

It is important to differentiate COVID-19 and influenza from other viral upper respiratory tract infections or bacterial pneumonia because there are specific treatments available for some respiratory viruses [4,5]. PCR tests for the rapid detection of respiratory pathogens have high sensitivity and specificity and are easy to apply, providing rapid results—particularly important in ED settings [1]. These diagnostic tests for respiratory viral infections targeting influenza virus, COVID-19, and respiratory syncytial virus (RSV) may change treatment modalities and isolation procedures [2,6]. Most hospitals face challenges due to the restricted number of isolation rooms designated for specific patient groups, such as oncologic patients. Hospital bed management may be improved with the use of rapid diagnostic tests applied in the ED to assist in decisions regarding hospital admission and appropriate bed selection [3,4,7]. Gaining insight into the epidemiology and causes of acute respiratory infections is vital for developing effective strategies for rapid treatment, prevention, and control [8].

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There are few studies evaluating viral agents in respiratory tract infections in the adult population, especially from Türkiye, and most focus on children or on lower respiratory tract infections [9,10]. The aim of this study was to investigate respiratory pathogens detected in adult patients presenting to the emergency department with symptoms of upper respiratory tract infection following the COVID-19 pandemic.

Materials and Methods

Design and Setting

This study was designed as a prospective, observational, single-center study conducted in an academic emergency department. Ethical approval was obtained from the institutional review board and relevant local committees before data collection (date: 08.02.2024, approval no.09.2023.1752, Marmara University Faculty of Medicine Clinical Research Ethics Committee).

Study Population and Sample

Between October 2023 and March 2024, consecutive patients admitted to the emergency department of a tertiary care center with a preliminary diagnosis of acute upper respiratory tract infection (URTI) were included in the study. The patients' electronic medical data at the time of admission and during treatment were collected and analyzed.

Inclusion and Exclusion Criteria

This study was conducted on adult patients (>18 years old) who presented to a tertiary care hospital emergency department. The inclusion criteria were as follows: (i) presence of symptoms consistent with acute URTI, such as fever, cough, sore throat, runny nose, nasal congestion, fatigue, weakness, nausea, vomiting, or diarrhea, along with a preliminary diagnosis of upper respiratory tract infection; (ii) having undergone a viral respiratory panel and COVID-19 PCR test requested by the emergency department physician; (iii) informed consent from the patient, a relative, or a legal guardian.

Patients were excluded if they had a fever persisting for more than seven days, had received antibiotics within the past week, or had not provided consent. Patients who withdrew their consent during the study or had incomplete data in the collected forms were also excluded.

Study Process and Data Collection

Patients with a preliminary diagnosis of upper respiratory tract infection who met the inclusion criteria were followed up and treated according to the recommendations of the emergency department physician. No additional tests or alternative treatments were administered by the study physicians. The patients' vital signs and demographic data at the time of admission were recorded. In addition, the results of nasal and oropharyngeal swab samples obtained from the patients were recorded.

The researcher asked the patient's primary physician whether they had considered prescribing antibiotics or antiviral drugs for the patient with suspected respiratory tract infection and recorded the response. At the time of answering this question, the physician was not aware of the nasal swab results.

Patients were divided into two groups: <50 years and >50 years. This classification was based on the significant increase in the frequency of chronic diseases (heart disease, diabetes, hypertension, cancer, etc.) after the age of 50 and associated lifestyle differences. The identified pathogens were further analyzed within these groups.

Oro-nasopharyngeal samples were obtained twice from each patient: one for the detection of respiratory pathogens and the other for SARS-CoV-2. Nasal and oropharyngeal swabs were first taken from the posterior oropharyngeal region and then from both nostrils, rotating 360 degrees within the nasopharynx.

Analysis of Respiratory Tract Viruses

The swabs were placed in capped tubes containing transport medium (NAT Transfer Tube, Bioeksen AR GE Technologies, Türkiye). The Bio-Speedy® Respiratory RT-qPCR MX-24 Panel (Bioeksen AR GE Technologies, Türkiye) was used to identify respiratory tract pathogens, which is a one-step reverse transcription and real-time PCR (RT-qPCR) test. This kit can differentiate 21 respiratory tract pathogens simultaneously (Influenza A, Influenza B, Human Coronavirus 229E, Human Coronavirus OC43, Human Coronavirus NL63, Human Coronavirus HKU1, Human Parainfluenza 1, Human Parainfluenza 2, Human Parainfluenza 3, Human Parainfluenza 4, Human Metapneumovirus, Enterovirus, Human Rhinovirus, Adenovirus, Human Bocavirus, Human Parechovirus, Respiratory Syncytial Virus A/B, Legionella pneumophila, Mycoplasma pneumoniae, Haemophilus influenzae, Bordetella pertussis, Streptococcus pneumoniae) in a single run.

Analysis of SARS-CoV-2

The swabs were placed in capped tubes containing transport medium (DiaVnat; TUSEB DiaVnat Extraction and Transfer Tube, Türkiye). SARS-CoV-2 analysis was performed using the DiaKit SARS-CoV-2 RT-qPCR Kit (TUSEB, Türkiye).

Both samples were analyzed using the Bio-Rad CFX96 device (Bio-Rad, USA).

Statistical Analysis

Statistical analyses were performed using Jamovi version 2.3.26 (The Jamovi Project, Australia). Continuous variables were reported as median and interquartile range (IQR, 25th–75th percentiles), depending on the distribution pattern. Categorical variables were presented as counts and percentages. Categorical variables were analyzed using the chi-square test. A p-value<0.05 was considered statistically significant within a 95% confidence interval.

Results

A total of 322 adult patients who presented to the emergency department with symptoms of upper respiratory tract infection were included in this study. The median age of the patients was 36 years (IQR:26–49), and 53.4% were male. Comorbidities and vital signs of the patients on admission are shown in Table 1. While the rate of those who had received the influenza vaccine was 8.1%, none had received a COVID-19 vaccine.

Among the collected samples, 221 (68.6%) tested positive for at least one respiratory pathogen, whereas no pathogen was detected in 101 (31.4%) patients. The most frequently identified pathogens were Influenza A (17.1%), COVID-19 (11.2%), and Influenza B (6.8%). Other detected viruses included Rhinovirus (5.6%), Human Bocavirus (5%), and Respiratory Syncytial Virus (6.2%) (Fig.1). Notably, coinfection with two pathogens was identified in 6.2% of cases. The most common coinfections involved Influenza A and RSV (Fig.2). Human metapneumovirus was more prevalent in patients >50 years of age (6.4% vs. 0.8%), while Influenza A and Rhinovirus were more prevalent in the younger group (18% vs.14.1% and 6.6% vs.2.6%, respectively) (Table 2).

Table 1. General characteristics of patients

Gender	Female	150 (46.6)
	Male	172 (53.4)
Age (year)		36 (26-49)
Duration of symptoms (day)		2 (2-3)
Fever (celsius)		36.7 (36.4-37.2)
SBP (mmHg)		128 (119-136)
DBP (mmHg)		75 (70-81)
Chronic medical conditions	Hypertension	53 (16.5)
	Diabetes mellitus	36 (11.2)
	Chronic lung disease	36 (11.2)
	Congestive Heart Failure	19 (5.3)
	Chronic Renal Failure	12 (3.7)
	Cancer	9 (2.8)
Have you received the influenza vaccine? (yes)		26 (8.1)
Have you had an UTRI in the past month? (yes)		54 (16.8)
Does anyone in your home have similar symptoms? (yes)		81 (25.2)

Data are median (IQR, 25th-75th percentile) or n (%); SBP: systolic blood pressure, DBP: Diastolic blood pressure; URTI: Upper respiratory tract infection.

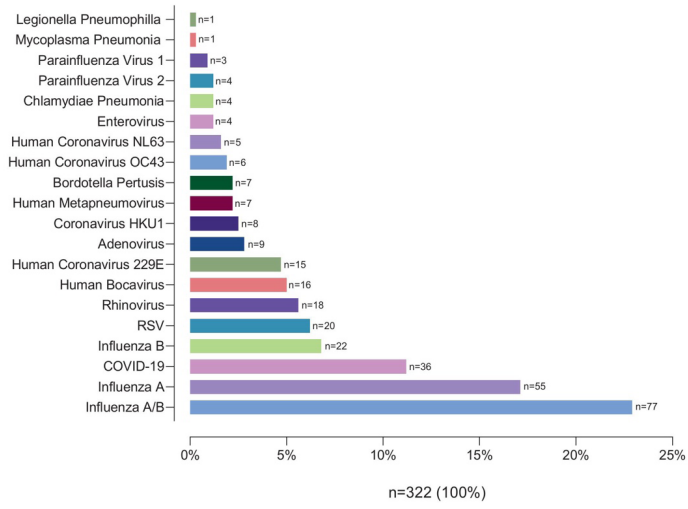

Figure 1. Distribution of respiratory pathogens in patients.

Table 2. Prevalence of respiratory pathogens in the age group

Results	18-49 years n=244	≥50 years n=78
Not detected	69 (28.3)	32 (41)
Adeno virus	7 (2.5)	2 (2.6)
Coronavirus HKU1	6 (2.5)	2 (2.6)
Human coronavirus NL63	3 (1.2)	2 (2.6)
Human coronavirus 229E	12 (4.9)	3 (3.8)
Human coronavirus OC43	6 (2.5)	0 (0)
Human metapneumovirus	2 (0.8)	5 (6.4)
Influenza A	44 (18)	11 (14.1)
Influenza B	18 (7.4)	4 (5.1)
Parainfluenza Virus 1	3 (1.2)	0 (0)
Parainfluenza Virus 2	4 (1.6)	0 (0)
Respiratory Synscytial Virus	17 (7)	3 (3.8)
Bordotella pertusis	6 (2.5)	1 (1.3)
Mycoplasma pneumoniae	0 (0)	1 (1.3)
Chlamydiae pneumoniae	2 (0.8)	2 (2.6)
Rhinovirus	16 (6.6)	2 (2.6)
Legionella pneumophila	0 (0)	1 (1.3)
Enterovirus	3 (1.2)	1 (1.3)
Human Bocavirus	12 (4.9)	4 (5.1)
Covid-19	30 (12.3)	6 (7.7)

Data are median n (%)

Table 3. The rates of antibiotic and antiviral prescriptions given to patients before swab results were available

Physicians were asked before the swab results were available	Detected influenza A/B n=77	Non-influenza A/B pathogen or not detected n=245	*p*
Have you considered prescribing antibiotics? (yes)	39 (51%)	67 (27%)	***<0.001***
Have you considered prescribing antivirals? (yes)	12 (16%)	14 (6%)	***0.006***
Chi-square test, p<0.05			

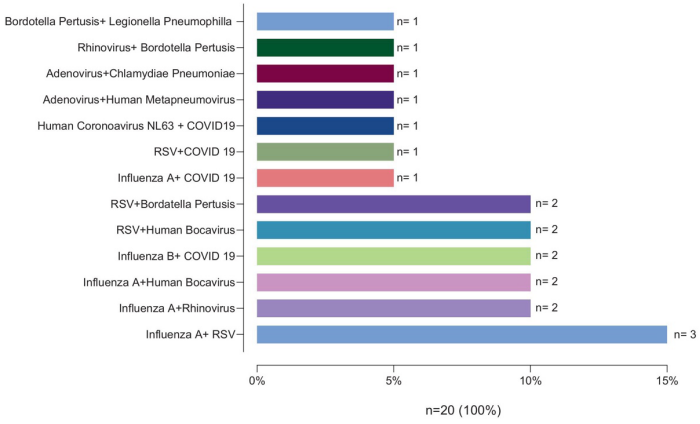

Figure 2. Co-pathogens detected groups.

Physicians stated that they would prescribe antibiotics to 32.9% of patients and antiviral treatment to 8.1% of patients before receiving swab results. The likelihood of prescribing antibiotics was significantly higher in patients with Influenza A/B compared to patients with non-influenza or undetectable pathogens (51% vs.27%) (Table 3).

Discussion

This study highlights the distribution of respiratory pathogens in patients presenting to the emergency department with upper respiratory tract infection after COVID-19.

With the rapid screening kit used, pathogens were detected in approximately 70% of patients, and the most common respiratory pathogen detected was Influenza virus in this study. This rate has been reported to range from 41.8% to 67.8% in a limited number of studies conducted in our country [9–11]. The positivity rate for the respiratory tract panel was 75.8% according to Uğur et al. [12] in 2022–2023. Remarkably high viral detection rates were reported in other countries, such as 85.3% in Japan and 88.7% in France; these were observed in studies from 2010–2011 that utilized the multiplex PCR technique [6,13,14]. Our study shows the increased vulnerability of older adults to Human Metapneumovirus. In a recent review, three distinct life stages are described regarding the risk of Human Metapneumovirus: Early Life (5–20% prevalence, attributed to immature immunity), Middle Life (5–10%, with increased prevalence in individuals with chronic illnesses), and Late Life (10–15%, influenced by immunosenescence and comorbidities). The increased occurrence of Human Metapneumovirus in older individuals observed in this study corroborates existing findings about their heightened vulnerability [15].

In our study, respiratory infections were often complex, as highlighted by the 6.2% coinfection rate, which can make diagnosis and treatment more challenging. The most frequent coinfections involved Influenza A with RSV, Rhinovirus, and Human Bocavirus. We found that multiple infections occurred at a lower rate compared to other studies conducted mostly in the pediatric age group [9,10]. In another study, the most frequently observed coinfections were rhinovirus/enterovirus-RSV (19.1%) across all age groups [12]. Some prior research suggests that viral co-infections can worsen illness, whereas other studies suggest the opposite due to lower viral loads [14,16,17].

The significant proportion of patients with undetected pathogens (31.4%) suggests that some infections may be due to bacterial etiologies or viruses not included in the testing panel. This result is similar to previous studies [1,18]. Some studies using multiplex respiratory pathogen PCR have reported lower detection rates in adults [1]. The positivity rate of PCR decreased as patient age increased, a finding consistent with other multiplex respiratory PCR studies reporting lower positivity in adults. This may be due to older adults shedding lower viral titers, necessitating more sensitive detection methods. Current multiplex PCR assays might lack the sensitivity needed to detect these lower viral loads in older patients [19,20].

Influenza A emerged as the most prevalent virus, followed by COVID-19 and Influenza B, consistent with prior epidemiological studies. A study by Çiçek et al. [21] found influenza viruses to be the most prevalent in adult patients, a finding supported by pre-COVID influenza surveillance data in Türkiye. According to a comprehensive review of multiplex respiratory panels [1], a study conducted by Yang et al. [22] also identified Influenza A as the most frequently detected pathogen in their cohort. Studies show that Influenza virus transmission is higher in winter than in summer. It has been emphasized that high humidity and warmer temperatures reduce the stability of the virus in the air and on surfaces, thereby decreasing transmission rates [23].

In our study, COVID-19 positivity was 11.2% overall. In another study from Türkiye, COVID-19 PCR positivity was detected in 142 patients (18.6%)[18]. Therefore, COVID-19 was found to be a significant contributor to upper respiratory tract infections [23].

An important finding of this study was the high rate of antibiotic prescription tendency (32.9%), despite the primarily viral etiology of these infections. This suggests potential overuse, which could contribute to antimicrobial resistance. These findings emphasize the importance of rapid viral diagnostic tests. Additionally, there was a low rate of antiviral treatment (8.1%), which may reflect hesitancy in prescribing antivirals.

Study Limitations

There are several limitations to this study. First, due to the single-center nature of the study, the results cannot be generalized. Second, the study included only patients who underwent viral panel testing, potentially introducing selection bias. Third, bacterial co-infections were not investigated.

Conclusion

In conclusion, this study provides important epidemiological data on viral respiratory infections after COVID-19. It also emphasizes the importance of rapid viral diagnostic tests in reducing unnecessary antibiotic use.

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Ethics Committee Approval: This study was approved by the Marmara University Ethics Committee (Date: 08.02.2024, Decision no: 09.2023.1752).

Informed Consent: Written informed consent was obtained.

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Authorship Contributions:

Concept: E.A., Ç.Ö., Ö.Y.; Design: E.A., Ç.Ö., Ö.Y.; Supervision: E.A., Ç.Ö., Ö.Y.; Resource: E.A., Ç.Ö., Ö.Y.; Materials: E.A., Ç.Ö., Ö.Y.; Data collection and/or processing: E.A., Ç.Ö., Ö.Y.; Analysis and/or interpretation: E.A., Ç.Ö., Ö.Y.; Literature review: E.A., Ç.Ö., Ö.Y.; Writing: E.A., Ç.Ö., Ö.Y.; Critical review: E.A., Ç.Ö., Ö.Y.

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