Predictors of cardiac injury during pericardiocentesis

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Background
For the management of pericardial effusion, pericardiocentesis plays an essential role. Despite advanced imaging methods, a substantial risk of complication persists.
Objectives
We aimed to predict the risk factors of pericardiocentesis complicated by cardiac injury and to assess the surgical outcome in complicated cases after echo-guided drainage.
Patients and methods
This observational study enrolled 134 patients with pericardial effusion who were scheduled for pericardiocentesis for drainage. The patients were divided into two groups: group I comprised 21 patients who required surgical intervention, and group II included 113 patients with successful uncomplicated pericardiocentesis.
Results
The mean age was 47.49±16.38 years, and 52.2% were males. There were no significant differences between both groups regarding the patients' characteristics. Hemodynamic instability was higher in the complicated (71.4%) than the noncomplicated (20.4%) group. Recurrent pericardiocentesis trials (≥2) were statistically higher in group I than group II (P<0.0001). The most common ethology was uremia, with no statistically significant difference between both groups. Multivariate analysis revealed that hemodynamic instability, more than two pericardiocentesis trial, and loculated effusion could predict cardiac injury during pericardiocentesis (odds ratio and 95% confidence interval were 24.206 and 3.632–161.315, 212.227, and 16.049–2806.445, and 16.113 and 1.765–147.058, respectively).
Conclusions
The presence of loculated effusion, hemodynamic instability, and the recurrence of effusion as two or more pericardiocentesis trials were potential risk factors of cardiac injury during pericardiocentesis. A pericardial window in high-risk cases is advised as a safe treatment procedure.

Keywords:
cardiac injury, pericardial effusion, pericardial window, pericardiocentesis

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Introduction

Pericardial effusion is a common illness with distinct causes [1]. The prevalence of pericardial effusion among the general population varies according to the population's demographic attributes and comorbidities. It has been reported to range from 0.8 to 5.7% [2,3].

Pericardial effusion in a limited pericardial space can affect patients' hemodynamics. A variety of symptoms develop with pericardial effusion, including dyspnea, tachypnea, chest pain, hypotension, and cardiac tamponade, which is a medical emergency. Hypotension or pulsus paradoxus are common signs of cardiac tamponade. It can be diagnosed without the presence of large amount of effusion and swinging heart [4,5].

Causes of pericardial effusion involve malignancy, chronic renal failure, pulmonary tuberculosis, and autoimmune diseases, besides the iatrogenic and idiopathic causes [6,7]. Recently, pericardial effusion was observed in coronavirus disease 2019 cases [8]. There is some variation in the etiologies reported from different countries or health care centers [4].

For diagnosis of pericardial effusion, chemical–physical, cytological, and microbiological examinations are the usual sequential steps [9]. M-mode and two-dimensional Doppler transthoracic echocardiography is necessary for the diagnosis, grading, pericardiocentesis procedure, and follow-up of pericardial effusion. It is a noninvasive technique that is easily used at the bedside with high sensitivity and specificity. Pericardial effusion appears as an echo-free space [10–12]. Computed tomography or MRI may be useful in patients with atypical hemodynamics and when the presence and severity of tamponade are doubtful [13,14].

For proper management of pericardial effusion, pericardiocentesis, pericardial window (PW), percutaneous catheter drainage, and balloon pericardiotomy can effectively drain the effusion. Selection of the proper surgical technique depends on patients' history and clinical conditions. Hence, the optimal approach for effusions treatment remains controversial [15].

Regardless of the etiology, symptomatic pericardial effusion is best managed through pericardiocentesis. It has both therapeutic and diagnostic purposes [3]. The procedure can be performed in emergency conditions, such as cardiac tamponade [1]. After pericardiocentesis, the patients' symptoms and hemodynamic abnormalities typically improve in most cases. Nevertheless, a few patients' symptoms might fail to improve or may even worsen after the procedure [12].

Complication rates for pericardiocentesis with and without echocardiography guidance are 3.5 and 1.2%, respectively [16]. Major complications include right atrium or ventricle laceration, injury to the coronary, mammary, or intercostal arteries; pericardial/epicardial thrombus; pericardial decompression; and death. Minor complications include vasovagal response with brief hypotension, nonsustained supraventricular tachycardia, occlusion of pericardial catheter, and pleuropericardial fistula [17,18].

Emergent surgical intervention may be required for treatment of cardiac injury during pericardiocentesis [19]. Urgent surgical intervention is indicated whenever the surgeon is faced with bleeding from aortic dissection, ventricular wall rupture due to acute myocardial infarction, or purulent effusion in unstable septic patients [9]. PW is an invasive technique that has lower morbidity and recurrence rates than pericardiocentesis. It allows direct exploration of the pericardium with complete drainage of pericardial cavity [9]. Right-side heart injury during pericardiocentesis is best repaired through the subxiphoid surgical approach [20]. Repairing cardiac tears might be difficult owing to heart movements. For instance, atrial lacerations might be clamped with a small Satinsky clamp to ease closure [21]. Hence, identifying the potential predictors of cardiac injury during pericardiocentesis may help clinicians improve treatment outcomes.

Meanwhile, in elective conditions, PW is usually recommended for recurrent neoplastic effusion, loculated effusion that is difficult to reached percutaneously, or when biopsy sample is needed [20,22].

PW could be also created by conventional heart surgery or video-assisted thoracoscopy [15]. Moreover, PW is approached through subxiphoid or transdiaphragmatic (Fig. 1) [23]. Both had similar rates of drainage effectiveness but different regarding perioperative pain, recurrence, and ventilatory support [24]. Therefore, the preferences of such approach depends on the surgeon experiences and skills [25].

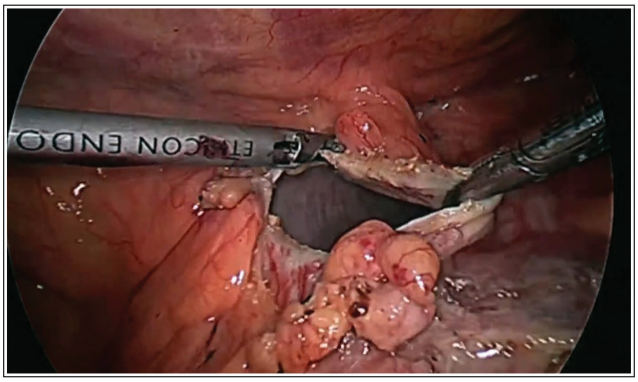
Although the incidence of PW-induced complications is relatively low, the technique still carries the risk of complications from general anesthesia, infection, uncontrolled bleeding, and cardiac arrest. For recurrent neoplastic effusion, a permanent PW is done for prevention of recurrence, but the surrounding tissue might seal this hole with increased risk of infection [26]. Transdiaphragmatic approach might be complicated with postpericardiotomy syndrome [27]. A paradoxical hemodynamic shock and instability were reported among 10% of neoplastic effusion cases after PW. Thus, meticulous postoperative monitoring should be considered [28].

The aim of this study was to evaluate the predictors and risk factors regarding cardiac injury in patients who underwent pericardiocentesis, and also to assess the surgical outcome in complicated cases following echo-guided drainage.

Patient and methodology

Our retrospective case–control study included total 134 cases that underwent pericardiocentesis for drainage of pericardial effusion. This study included cases from two tertiary centers after getting the approval from ethical committee and patients. All of the data were collected from February 2018 to February 2021. Cases were

Figure 1



Pericardial window thoracoscopic.

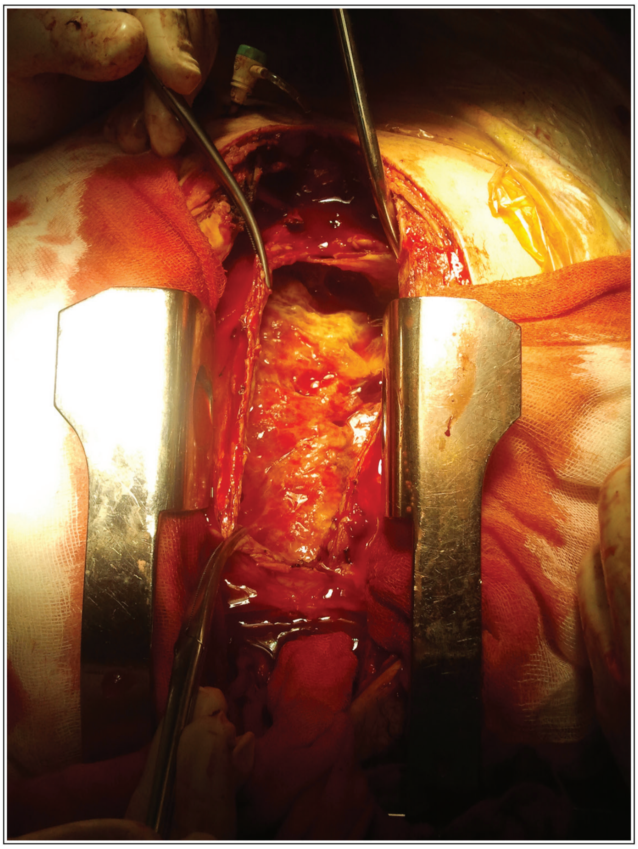
divided into two groups: group I (n=21), complicated group (these cases required urgent referral for surgical intervention), and group II (n=113), noncomplicated group (these cases completed their procedure without complications).

Inclusion criteria were cases that developed pericardial effusion and required drainage with pericardiocentesis as the first option and the complicated group in those cases during the procedure. Exclusion criteria were all emergency cases of cardiac trauma either penetrating or blunt trauma, cases that had large pericardial effusion or tamponade after open-heart surgery, and cases who were referred early as elective cases for PW or histopathological study.

Surgical techniques

After informed consents were taken from these cases, the patients underwent surgical intervention under general anesthesia after full monitoring and resuscitation as needed according to the protocol. No case developed cardiac arrest before the procedure. All cases underwent exploration either through left thoracotomy or median sternotomy according to the situation and suspected injury site after clinical evaluation and the availability of perfusion team as emergency (Fig. 2).

Figure 2



Sternotomy in loculated pericardial effusion after injury post pericardiocentesis.

After exposure and suction, the bleeding point had been localized with difficulty while resuscitative measures were done. In seven cases, heart lung machines were used to support the circulation during repair. In all cases, pericardial patches were taken to support the suture site to avoid more shearing action upon the cardiac muscle. Moreover, Teflon pledgets also were used to support weak points to a lesser extent using prolene 4/0 (Fig. 3).

In the remaining cases, off pump repair was performed after securing bleeding, and in a small number of cases, Tacocil patch was used to secure bleeding after primary suture.

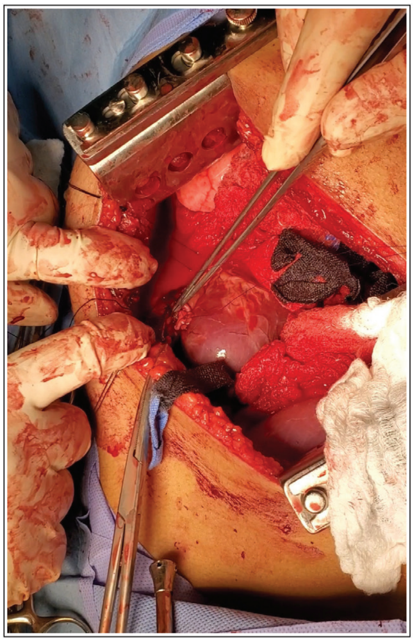
After repair, the chest wall was closed in layers either in thoracotomy or sternotomy cases. In these cases, there was no chance to do minimally invasive PW thoracoscopy as in elective referral cases. Pericardiocentesis echo-guided subxiphoid was the original approach in all of the cases.

Instructions and postoperative follow-up: all cases in group II were shifted to ICU ventilated for follow-up, with gradual weaning off inotropes if present and adjust hemodynamic status.

Statistical analysis

Data were analyzed using SPSS, version 22.0 (SPSS Inc, Chicago, ILL Company, USA). Categorical variables are presented as numbers and percentages and were compared using the χ^2 and Fisher's exact

Figure 3



Right ventricular repair with pericardial patch.

tests as convenient. Continuous variables are expressed as the mean±SD and were compared using Student's unpaired *t* test or the Mann–Whitney *U* test.

For multivariate analyses, logistic regression models were used to determine the risk factors predicting cardiac injury. All reported *P* values were two sided, and a value of *P* value less than 0.05 was considered statistically significant.

Results

Table 1 shows the epidemiology and characteristics of the patients. The total number of cases was 134 patients, comprising 64 (47.8%) females and 70 (52.2%) males. Group I (complicated group after pericardiocentesis) included 21 (15.7%) patients, comprising 11 (52.4%) females and 10 (47.6%) males. Group II (noncomplicated cases after pericardiocentesis) included 113 (84.3%) patients, comprising 53 (46.9%) females and 60 (53.1%) males. No significant difference in patients' characteristics was detected.

The mean age for total patients was 47.49±16.38 years. Group I had a mean age of 43.52±13.90 years, whereas group II had a mean age of 48.22±16.75 years (*P*=0.229). The mean BMI in total patients was 26.46±5.40. Group I had a mean BMI of 27.86±4.16 compared with 26.19±5.58 in group II (*P*=0.197), with no significant difference. Ejection fraction (EF) preoperatively in both groups was 53.43±13.34. Group I had mean EF of 49.52±13.01, whereas group II had a mean EF of 54.16±13.33, with insignificant difference (*P*=0.144). A total of 46 (34.3%) patients are diabetic in both groups, within eight (38.1%) patients in the first group versus 38 in the second group (33.6%), with insignificant difference (*P*=0.692).

Symptoms upon first presentation were significantly different between two groups, with *P* value less than 0.0001, as shown in Table 1 and Fig. 4.

Regarding hemodynamic instability, there was a significant difference, as the number was higher in the complicated group (*n*=15, 71.4%, vs. *n*=23, 20.4%) in the pericardiocentesis group, with *P* value less than 0.0001.

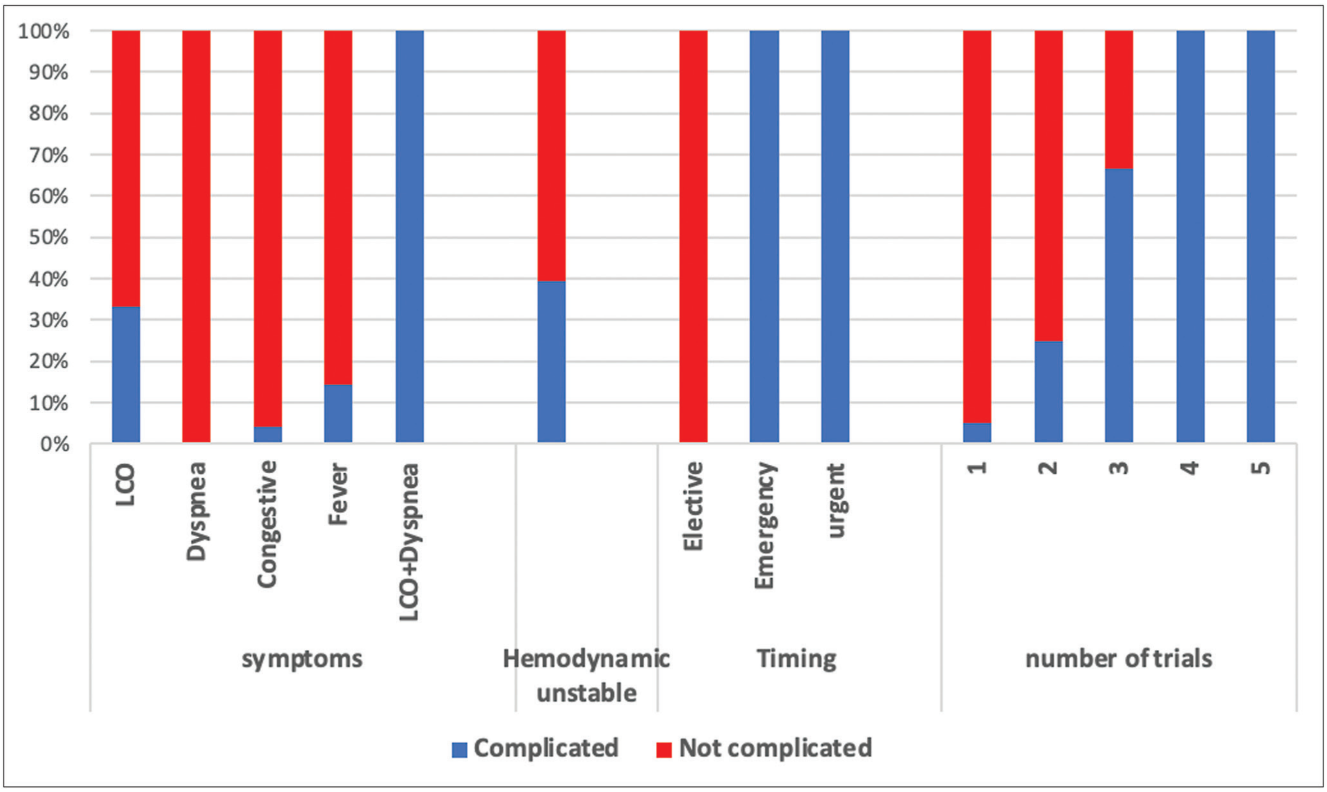
The number of pericardiocentesis trials (recurrent cases) was significantly different (*P*<0.0001). In the complicated group, the number of patients who had one, two, three, four, and five trials was five (23.8%),

Table 1 Patients' characteristics

	Total (134) [*n* (%)]	Complicated group I (21) [*n* (%)]	Noncomplicated group II (113) [*n* (%)]	*P* value
Age (years)	47.49±16.38	43.52±13.90	48.22±16.75	0.229
BMI	26.46±5.40	27.86±4.16	26.19±5.58	0.197
EF %	53.43±13.34	49.52±13.01	54.16±13.33	0.144
Sex				
Female	64 (47.8)	11 (52.4)	53 (46.9)	0.644
Male	70 (52.2)	10 (47.6)	60 (53.1)	
DM	46 (34.3)	8 (38.1)	38 (33.6)	0.692
Smoking	41 (30.6)	7 (33.3)	34 (30.1)	0.767
Symptoms	LCO	12 (57.1)	24 (21.2)	<0.0001
	Dyspnea	0	12 (10.6)	
	Congestive	3 (14.3)	71 (62.8)	
	Fever	1 (4.8)	6 (5.3)	
	LCO+dyspnea	5 (23.8)	0	
Hemodynamic unstable		15 (71.4)	23 (20.4)	<0.0001
Timing	Elective	0	9 (7.9)	<0.0001
	Emergency	13 (61.9)	0	
	Urgent	8 (38.09)	0	
Trials	1	5 (23.8)	97 (85.8)	<0.0001
	2	4 (19.0)	12 (10.6)	
	3	8 (38.1)	4 (3.5)	
	4	3 (14.3)	0	
	5	1 (4.8)	0	
Size/loculation	Moderate loculated	3 (14.2)	7 (6.2)	
	Moderate	2 (9.5)	9 (7.9)	
	Large loculated	8 (38.09)	9 (7.9)	<0.0001
	Large	4 (19.0)	80 (70)	
	Tamponade	4 (19.0)	8 (7.1)	

DM, diabetes mellitus; EF, ejection fraction.

Figure 4



Clinical presentation, timing for surgical intervention, and number of pericardiocentesis trials.

Table 2 Etiology of pericardial effusion for both groups

Etiology	Complicated group I (*N*=21) [*n* (%)]	Not complicated group II (*N*=113) [*n* (%)]	*P* value
Renal	10 (47.6)	43 (38.1)	0.41
ICM/DCM	0	17 (15.0)	0.073
IHC injury	2 (9.5)	0	0.024
Liver	2 (9.5)	12 (10.6)	1
Mesothelioma+malignancy	4 (19.0)	11 (9.7)	0.254
TB	2 (9.5)	6 (5.3)	0.611
Not specific	0	7 (6.2)	0.596
Trauma	1 (4.7)	1 (0.9)	0.290
Connective tissue disease	0	13 (11.5)	0.22
Postcardiac surgery	0	3 (2.7)	1
Total	21 (100)	113 (100)	

IHC, immunohistochemistry; TB, tuberculosis.

four (19.0%), eight (38.1%), three (14.3%), and one (4.8%), respectively. In the noncomplicated group, the number of patients who had one, two, three, four, and five trials was 97 (85.8%), 12 (10.6%), four (3.5%), zero (0%), and zero (0%), respectively.

The size of effusion in the initial TEE was also significantly different, with higher moderate, moderate loculated, large loculated, and tamponade effusion in group I patients, whereas large size effusion was higher in group II ($P<0.0001$).

Table 2 shows the etiologies of cardiac effusion. The only significant difference between the two groups was noted in immunohistochemistry injury etiology, with two (9.5%) patients in group I and zero in group II, with P value of 0.024.

Table 3 shows the histopathological/cytological findings for 134 patients. No significant difference was noted between two groups. In 87 (64.9%) patients, the effusion analysis result was negative. Mesothelioma was diagnosed in 11 (8.2%) patients, eight (5.97%) patients had metastasis, eight (5.97%) patients had tuberculosis granuloma, and 7 (5.2%) patients had systemic lupus erythematosus. Other findings included amyloid and nonspecific granuloma, as seen in 13 (9.7%) patients.

The sites of injuries found intraoperative in group I were distributed as follows: right ventricular injury (*n*=9, 44.9%), right ventricular outflow tract injury (*n*=2, 9.5%), left ventricular trauma (*n*=5, 23.8%), coronary injury (*n*=4, 19.0%), and broken sheath (*n*=1, 4.8%) (Table 4).

The cause of shift to the operating room was owing to the following cases: cardiac tamponade with recurrent tapping (*n*=1, 0.9%), large loculated failed tapping (*n*=4, 3.5%), moderate loculated failed tapping (*n*=1, 0.9%), and moderate effusion with pus or need tissue biopsy (*n*=3, 2.7%) (Table 4).

The need for surgical exploration through sternotomy was done in 10 (47.6%) cases, whereas left thoracotomy was done in 11 (52.4%). Subxiphoid incisions were not used in these cases because of limited operative field for unplanned surgical intervention needed (Table 4).

Table 3 Histopathological/cytological findings

	Frequency	Percent
Normal	87	64.9
TB granuloma	8	5.97
Mesothelioma	11	8.2
Metastasis lesions	8	5.97
SLE	7	5.2
Other CT diseases	6	4.5
Amyloid	4	2.98
Nonspecific granuloma	3	2.2
Total	134	100.0

CT, connective tissue; SLE, systemic lupus erythematosus; TB, tuberculosis.

Table 4 Causes of shift to surgery in group II and operative finding

Cause of injury in group I (operative finding) [*n* (%)]	
RV injury	9 (42.9)
RVOT injury	2 (9.5)
LV injury	5 (23.8)
Coronary injury	4 (19.0)
Broken sheath	1 (4.8)
Cause of shift to OR in group I [*n* (%)]	
Cardiac tamponade with recurrent tapping	1 (4.8)
Large loculated failed tapping	4 (19)
Moderate loculated failed tapping	1 (4.8)
Moderate effusion with pus or need tissue biopsy	3 (14.3)
Moderate to large effusion with posterior collection, failed tapping	4 (19)
Cardiac tamponade not responding for resuscitation	8 (38.1)
Surgical incisions	
Sternotomy	10 (47.6)
Thoracotomy	11 (52.4)
Subxiphoid	0

LV, left ventricular; RV, right ventricular; RVOT, right ventricular outflow tract.

Table 5 shows the complications that occurred postoperatively in group I (*n*=21 patients). There were no complications documented in 14 (66.6%) patients, whereas bleeding was seen in three (14.2%) patients, disseminated intravascular coagulopathy (DIC) in two (9.5%) patients, infection in one (4.7%) patient, and burst chest in one (4.7%) patient. The need for heart lung machine to support the circulation was seen in seven (33.3%) patients, and postoperative inotropes were required in four (19%) patients.

Regarding the outcomes in both groups, hospital stay was comparable between the two groups, with significant difference (group I: 14.24 ± 7.93 days, and group II: 9.93 ± 5.03 days; *P*=0.016). ICU stay was nonstatistically significant between group I (3.57 ± 1.59) and group II (2.98 ± 3.09 days), with *P* value of 0.055. Mortality was documented in two (9.5%) cases in the complicated group versus two (1.8%) cases in group II (*P*=0.116) as sequelae of DIC and infection. The amount of pericardial effusion in the postprocedural echocardiography showed significant reduction in group I in comparison with group II (*P*=0.001), as shown in Table 6.

Multivariate analysis of risk factors for getting cardiac injury during pericardiocentesis demonstrated that the only significant predictors are hemodynamic instability [odds ratio (OR)=24.206; 95% confidence interval (CI)=3.632, 161.315, *P*=0.001], number of pericardiocentesis trials more than 2 (OR=212.227; 95% CI=16.049, 2806.445, *P*<0.0001), and the presence of loculated effusion preprocedurally (OR=16.113; 95% CI=1.765, 147.058, *P*=0.014), as shown in Table 7 and Fig. 5.

Discussion

A major complication of pericardiocentesis is puncturing the heart. Identifying the potential risks of cardiac injury during the procedure is crucial to improve patient outcome [18]. This study aimed to evaluate the predictors and risk factors regarding cardiac injury in patients who underwent pericardiocentesis and

Table 5 Post OR complications in group I

Complications	*N*=21 [*n* (%)]
No complication	14 (66.6)
Bleeding	3 (14.2)
DIC	2 (9.5)
Infection	1 (4.7)
Burst chest	1 (4.7)
Needed HL machine	7 (33.3)
Inotropes postoperative	4 (19)

DIC, disseminated intravascular coagulopathy; HL, heart lung.

Table 6 Outcome results in both groups

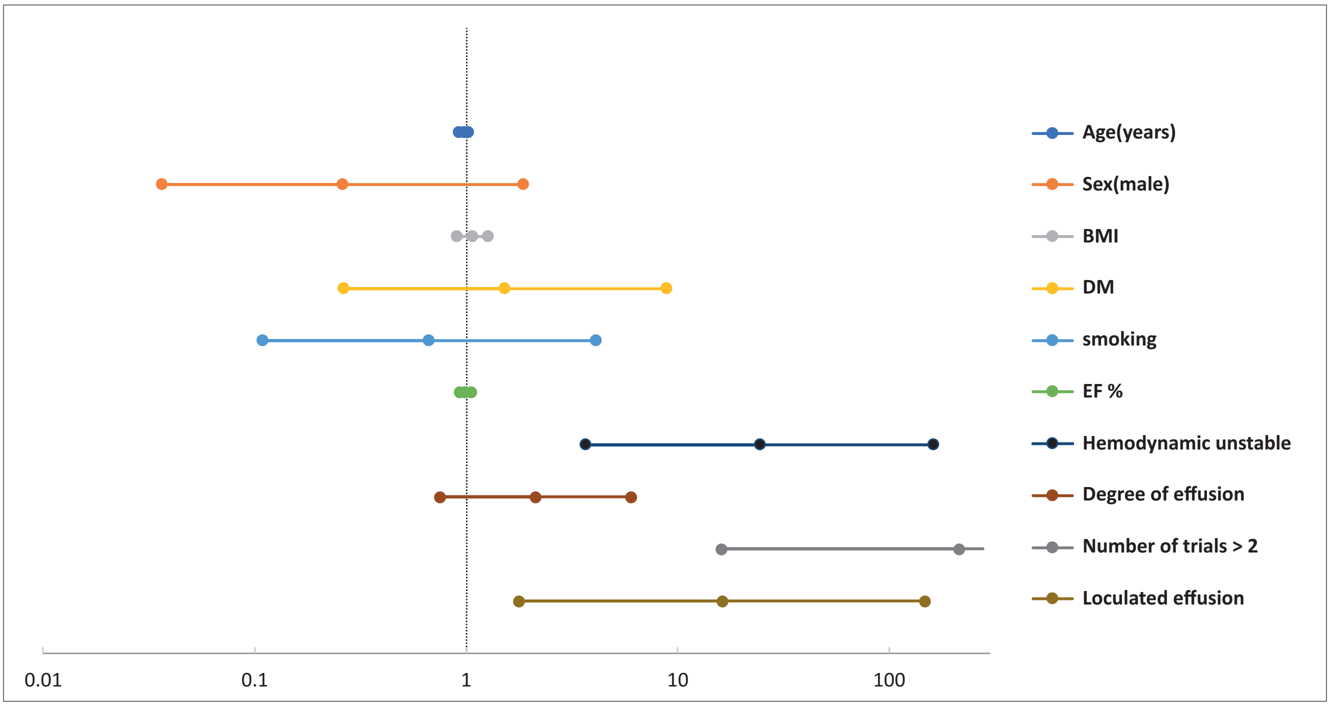
	Complicated (21) [*n* (%)]	Not complicated (113) [*n* (%)]	*P* value
Hospital stay (day)	14.24±7.93	9.93±5.03	0.016
ICU stay (day)	3.57±1.59	2.98±3.09	0.055
Mortality	2 (9.5)	2 (1.8)	0.116
Size of pericardial effusion post drainage (echo)			
Nil	7 (33.3)	8 (7.1)	
Mild	12 (57.1)	75 (66.4)	0.001
Moderate	2 (9.5)	30 (26.5)	

Table 7 Predictors of cardiac injury

	Adjusted OR	95% CI		*P* value
		Lower	Upper	
Loculated effusion	16.113	1.765	147.058	0.014
Number of trials >2	212.227	16.049	2806.445	<0.0001
Age (years)	0.965	0.914	1.018	0.191
Sex (male)	0.259	0.036	1.853	0.179
DM	1.509	0.260	8.758	0.646
BMI	1.062	0.896	1.258	0.489
smoking	0.663	0.108	4.086	0.658
Hemodynamic unstable	24.206	3.632	161.315	0.001
EF %	0.983	0.925	1.046	0.595
Degree of effusion	2.118	0.748	5.998	0.158

CI, confidence interval; DM, diabetes mellitus; EF, ejection fraction; OR, odds ratio.

Figure 5



Multivatiant analysis for peridictors of cardiac injury during pericardiocentesis.

to assess the surgical outcome in complicated cases following echo-guided drainage.

Analysis of the patients' characteristics did not show any significant differences between both groups. The baseline characteristics agree with other studies from Pakistan [18] and Saudi Arabia [29]. However, different results were reported from Taiwan [30], where the percentage of patients older than 80 years increased to 15% in 2010. The etiologies could vary because of different epidemiology, hospital setting, and protocol [4].

Symptoms at first presentation and hemodynamic instability were significantly different between both groups. Accumulation of more than 50 ml fluid can lead to hemodynamic instability including hypotension and cardiogenic shock that resist fluid therapy and inotropes. Cardiac compression and impaired cardiac filling may show manifestations of cardiac tamponade [31]. It has been reported that patients' presentation with hemodynamic instability could be associated with complicated pericardiocentesis [32].

The current study displayed that largely and moderately loculated pericardial effusions had complications during pericardiocentesis that needed surgical intervention, whereas effusions that were accessible had uncomplicated pericardiocentesis. This agrees with earlier research work where effusions of little amount in the apical space or localized at posterolateral segment may not be reached from the pericardiocentesis approach. Cardiac injury might occur during the procedure, and the needle might puncture the heart. It is safer that pericardiocentesis is performed in a well-prepared operating room. When the procedure is complicated, it would be easily to convert to urgent surgery [32,33].

We found that uremic effusion was the leading cause of pericardial effusion in both groups. Comparable results were reported from Asir Region, Saudi Arabia [34]; however, a more recent study from the Western Region of Saudi Arabia [29] revealed that malignancy was the commonest cause of the effusion. Such findings may possibly reflect the dominant diseases in these regions. Depending on the location and populations of the survey, causes of pericardial effusion vary. In less developed countries, such as South Africa, tuberculosis predominates. However, in advanced countries, neoplastic effusion and cardiac surgery complications were the most common causes [2,5,35].

A cytological analysis is essential step for diagnosis neoplastic etiology. It may also signify the treatment and follow-up of the underlying disease [36]. In the current study, mesothelioma was diagnosed in 8.2% of the patients, whereas metastasis was detected in 5.97% of the cases. Albugami *et al.* [29] found a higher percent (18%) of malignant cytology. Whenever there is no definite clinical diagnosis, it has been suggested to apply cytological tests [37].

Right ventricular injury was the commonest finding during surgical exploration after pericardiocentesis, which was in line with earlier reports from Shih *et al.* [38] and Horr *et al.* [32]. When minimal effusion fluid was detected in the apical and anterior space, the risk of right ventricular injury increases during pericardiocentesis. Additionally, blind subxiphoid approach increases right ventricular injury at the inferior surface [11]. Cardiac tamponade not responding to resuscitation was the commonest indication for shifting to cardiac exploration after pericardiocentesis. Such life-threatening complications are difficult to be treated without cardiac surgery. Furthermore, blind pericardiocentesis without echocardiographic or fluoroscopic guidance has a higher complication incidence [7]. To reduce the complication risks, echocardiographic guidance is crucial for continuous visualization of the needle and appropriate selection of the puncture site, which has been associated with lower rates of cardiac perforations [5,9,39].

After surgical exploration, a great percentage (52.4%) of patients survived without complication. However, seven (33.3%) patients needed heart lung machine. This might arise from the general anesthesia required during the surgical exploration. Anesthetic drugs may cause venodilation. Positive-pressure ventilation leads to elevation of intrathoracic pressure, reduction of the venous return, and shock.

For postprocedural monitoring, the optimum duration has not been known. It depends on symptom duration and resolution [40]. In our study, the complicated group required longer duration of hospital stay than the noncomplicated group. This could be attributed to the longer time needed for follow-up and full recovery after surgical intervention.

The mortality rate showed no significant difference between both groups, which was also reported by earlier research [32]. Mortality was quite low compared with previous reports. This could be attributed to the sequelae of DIC and infection and the relatively lower incidence of malignant fluid effusions than previous studies [30].

Regarding reaccumulation of the effusion, postprocedural echocardiography showed significant reduction in patients who underwent surgery compared with those with uncomplicated pericardiocentesis. Other researchers also reported that reaccumulation of pericardial effusion was more common after pericardiocentesis. Leaving a pericardial drain in place after the initial procedure can lower the risk of fluid reaccumulation [32].

Multivariate analysis of risk factors demonstrated that hemodynamic instability can significantly predict cardiac injury during pericardiocentesis. Comparable findings were previously reported where hemodynamic instability was related to hospital mortality and pericardiocentesis complication. Hemodynamic instability might result from the effects of general anesthesia and vasopressors used [32,41].

In additions, more than two pericardiocentesis trials were considered a predictor of cardiac injury. Inaccurate introduction/excursion of the drainage catheter can injure the right atrium and perforate of great vessels such as superior vena cava or the inferior vena cava [42]. Hence, highly skilled clinicians should perform pericardiocentesis in a cardiothoracic operating room in the event of more than a trial [40].

The loculated effusion could predict cardiac injury during pericardiocentesis. Wong *et al* [43] highlighted the critical significance of the amount and location of pericardial fluid. The more the fluid between the pericardium and the heart, the less likely the chance of a complication. Moreover, the anterior subxiphoid approach could not reach the posteriorly loculated effusions.

This was a retrospective study that was subjected to selection bias. The study was performed on a relatively small number of patients at two centers, which may not reflect the patient characteristics and etiologies seen at other institutions. In addition, long-term follow-up was not available. However, our results may pave the way for larger, multicenter studies recruiting patients based on sample size calculation.

In conclusion, clinicians should have a high index of suspicion for cardiac injury during pericardiocentesis, particularly when confronted with patients' hemodynamic instability, more than two pericardiocentesis trials, or the presence of loculated pericardial effusion.

Limitations

There were a small number of cases in the complicated group, which need more attention for further analysis. This study did not include patients who were referred electively from the start for surgical intervention, as well as cases after operation and those cases that came in cardiac tamponade after trauma or with unexplained etiology. Cases that developed tamponade during left heart catheterization or pacemaker insertion were excluded. Cases with pericardial effusion who needed drainage thoracoscopic were not included in these cases as emergency basis.

Conclusion

The presence of loculated effusion, hemodynamic instability, and recurrence of effusion as two or more pericardiocentesis trials were potential risk factors of cardiac injury during pericardiocentesis. PW in high-risk cases is advised as a safe treatment procedure.

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Conflicts of interest

There are no conflicts of interest.

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