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Predictors of Positive Subxiphoid Pericardial Window in Stable Patients with Penetrating Injuries to the Precordial Region

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Abstract

Background: Subxiphoid pericardial window (SPW) remains a valuable diagnostic tool for patients at risk of occult cardiac injuries. However, how to select patients that could benefit from this procedure remains unclear. We aimed to identify clinical predictors of positive SPW in patients with penetrating precordial injuries.

Materials and methods: Prospective data collection of 183 patients who underwent SPW for the exclusion of penetrating cardiac injuries during 2002 – 2004 at a level I trauma centre in Cali, Colombia. Patient's demographics, clinical characteristics, and injury information were obtained. Independent predictors of positive SPW were assessed using stepwise logistic regressions.

Results: There were 41 positive SPW (22.4%). Unadjusted analyses demonstrated that stab/knife wounds (OR 2.48, 95% CI 1.17–5.25, p = 0.017), single wound (OR 14.61, 95% CI 1.9–110, p = 0.009), and clinical signs of pericardiac tamponade (OR 8.52, 95% CI 3.92–18.4, p < 0.001) were associated with increased odds of positive SPW. Conversely, systolic blood pressure (0.98, 95% CI 0.96–0.99) and stable physiological index (OR 0.31, 95% CI 0.14–0.65, p = 0.002) were associated with decreased odds. In multivariable analyses, signs of pericardiac tamponade (OR 6.37, 95% CI 2.78–14.6, p < 0.001), and single injuries (OR 12.99, 95% CI 1.6–102.7, p = 0.015) remained as independent predictors of positive SPW.

Conclusion: Emphasis on early recognition of the clinical signs of pericardiac tamponade could be the most important factor for the identification of occult cardiac injuries. Patients with multiple wounds to the precordial region who reached the hospital may not benefit from a SPW. However,

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high level of awareness is important because the incidence of occult cardiac injuries is not negligible.

RESUMEN

La ventana pericárdica subxifoidea (SPW) sigue siendo una valiosa herramienta de diagnóstico para los pacientes con riesgo de lesiones cardíacas ocultas. Sin embargo, la forma de seleccionar a los pacientes que podrían beneficiarse de este procedimiento sigue siendo poco clara. El objetivo fue identificar predictores clínicos de SPW positivos en pacientes con lesiones penetrantes precordiales.

Recolección de datos prospectivos de 183 pacientes a los que se le realizo SPW para la exclusión de lesiones cardiacas penetrantes durante el 2002 hasta 2004 en un centro de trauma de nivel I en Cali, Colombia. Se obtuvo datos demográficos del paciente, características clínicas y la lesión. Los predictores independientes de SPW positivo se evaluaron mediante regresión logística paso a paso.

Hubo 41 positivos para SPW (22,4%). Análisis no ajustados demostraron que las heridas de arma blanca/cuchillo (OR 2.48, IC 95%: 1,17 a 5,25; p = 0,017), sola herida (OR 14,61; IC del 95%: 1,9 a 110, p = 0,009), y los signos clínicos de taponamiento pericárdico (OR 8,52, IC 95% 3,92 a 18,4, p < 0,001) se asociaron con mayores probabilidades de un SPW positivo. Por el contrario, la presión arterial sistólica (CI 0,98, 95%: 0,96 a 0,99) y el índice fisiológico estable (OR 0,31; IC del 95%: 0,14 a 0,65; p = 0,002) se asociaron con una disminución de las probabilidades. En el análisis multivariable, los signos de taponamiento pericárdico (OR 6,37; IC del 95%: 2,78 a 14,6, p < 0,001), y lesiones individuales (OR 12,99, 95% CI 1,6 a 102,7, p = 0,015) permanecieron como predictores independientes del SPW positivo.

El énfasis en el reconocimiento temprano de los signos clínicos de taponamiento pericárdico podría ser el factor más importante para la identificación de las lesiones cardíacas ocultas. Los pacientes con múltiples heridas en la región del pecho que llegaron al hospital no se pueden beneficiar de un SPW. Sin embargo, un alto nivel de conciencia es importante porque la incidencia de las lesiones cardíacas ocultas no es despreciable.

Keywords

Cardiac tamponade; Penetrating cardiac injury; Precordial region; Subxiphoid pericardial window

INTRODUCTION

Penetrating cardiac trauma is a highly lethal injury, with relatively few victims surviving long enough to reach the hospital with signs of life, even with improvements in organized emergency medical transport systems.[1,2] More frustrating, is the fact that mortality has not changed much, even in major trauma centre in the United States (US) over what period of time.[3] Rapid bleeding into the pericardium favors clotting and as pericardial fluid accumulates, a decrease in ventricular filling occurs, leading to a decrease in stroke volume, consequently leading to compensatory tachycardia and increased right heart filling pressures. The limits of right-sided distensibility are reached as the pericardium fills with blood, and the septum shifts toward the left side, further compromising left ventricular function and producing the clinical picture of tamponade. However, patients with penetrating

cardiac injury can present with a clinical spectrum from full cardiac arrest to asymptomatic with normal vital signs.[2] Decisions to aggressively intervene are made more easily in the patients with obvious circulatory collapse upon arrival to the emergency department (ER). Nevertheless, two thirds of the patients could present with transient or no signs of hemodynamic instability.[4]

The diagnosis of hemopericardium can be made by ultrasonography of the pericardial sac, but the exam is highly dependent on the operator skills, it has a highly sensitivity and specificity, and the presence of associated hemothorax can significantly increase false negative reports.[5] A subxiphoid pericardial window (SPW) is a useful intervention when there is a possible occult cardiac injury. The sensitivity and specificity are near 100 and 92%, respectively. The procedure is quick, simple, and easy to perform. However, it is invasive and the magnitude and true incidence of its complications have not been completely defined.[6] There has been a significant controversy in the past with regards to its indications. To our knowledge, how to select patients that could benefit from this procedure remains unclear.[2] Therefore, the aim of this study was to identify clinical predictors of positive SPW in stable patients with penetrating injuries to the precordial region.

MATERIALS AND METHODS

This prospective observational study took place during 2000 – 2004 at an urban level I trauma centre in Cali, Colombia, a city characterized by a high incidence of interpersonal violence.[7] Injured patients admitted to the emergency department were assessed initially with the advanced trauma life support (ATLS) protocols.[8] Patients with penetrating injuries to the precordial region were selected. Penetrating injuries to the precordial region were defined as a stab/knife or firearm wounds inferiorly to the clavicles, superiorly to the costal margins, and medial to the mid clavicle lines. In addition, patients with thoracoabdominal firearm wounds with bullet tracts suspected to be in close proximity to the heart were also included. Patients with obvious cardiac injuries presenting with hemorrhagic shock, with pulseless electrical activity, or with cardiac arrest witnessed by medical personnel but still with signs of life were immediately transferred to the immediately adjacent operating room (OR) for emergency or resuscitative thoracotomy as necessary and were excluded from the study. Patients with drainage of >1.5 l of blood after chest tube placement or >200 ml per hour of blood from thoracostomy were also transferred to the OR for emergency/urgent thoracotomy and were also excluded.

Patients with hemodynamic stability, who had no other indication of thoracotomy, but with a high suspicion for occult cardiac injuries, were taken to the OR for SPW. In a supine position under general anesthesia, an 8 to 10 cm incision was made in the midline over the xiphoid process through the skin and subcutaneous tissue, achieving hemostasis by electrocautery. The xiphoid process was dissected and displaced cephalic and the adipose tissue beneath the xiphoid was separated with blunt dissection until, by digital palpation of the transmitted cardiac impulse, the pericardium was localized. When hemodynamic status allowed, patients were placed in a reverse Trendelenburg position to allow the pericardium to descend and become more accessible. The pericardium was firmly grasped and the surgical area cleared with normal saline to remove blood, to reduce the likelihood of a false

positive result. A longitudinal incision of approximately 1 cm was made in the pericardium, meticulously avoiding laceration of the underlying epicardium. The characteristic of the effluent was observed. When necessary, suction catheters were passed into the incision to liberate clots and to allow blood to escape through the aperture.[9] Patients in whom the cardiac wound was discarded by other method were also excluded.

Patients' demographics, injury mechanism, and clinical findings were recorded at emergency department. Physiologic alterations accompany the injured heart and serve to stratify the group of patients that could benefit from resuscitative thoracotomy; therefore, patients were stratified according to the physiological index (PI) described by Ivatury et al[10] based on the degree of transient physiologic deterioration. The PI was calculated from patients' clinical status on admission.

Beck's triad (low systolic blood pressure (SBP), raised venous pressure, muffled cardiac sounds) and Kussmaul's sign (jugular venous distention on inspiration) are classic presentations of pericardial tamponade; any of these clinical signs on admission were recorded. Information regarding the surgical intervention, type and characteristics of the procedures, surgical findings, and anatomic description of injuries were obtained from the operative reports. Main outcome measure was whether the SPW was positive or not. A positive SPW was defined as the presence of blood in the pericardial sac in the form of active bleeding, blood clots, or blood staining of the pericardial fluid.

Variables were analyzed descriptively by the presence of outcome. Qualitative variables were summarized using relative and absolute frequencies and comparisons were performed using Chi-squared or fisher's exact tests. Continuous variables were summarized using means, standard deviations (SD), medians, and inter quartile ranges (IQR) and comparisons were performed using nonparametric tests given their non-normal distributions. To obtain a basic idea of the association of predictors for positive SPW, simple logistic regressions were performed, calculating odds ratios (OR), 95% confidence intervals (CI), and p-values. Full assessment of predictors independently associated with a positive SPW was conducted using multivariable logistic regressions and likelihood ratio tests in a step-wise manner, removing variables if the associated regression coefficient had a p-value greater than 0.1. Quality of the final prognostic model was assessed in terms of calibration by the Hosmer-Lemeshow goodness-of-fit (GOF) test and in terms of discrimination with the area under the receiver operation characteristic curve (AUC). The accuracy of SPW for the diagnosis of cardiac injuries was presented in terms of sensibility, specificity, likelihood ratios and predictive values.

RESULTS

During the study period, 287 patients with penetrating injuries to the precordial region or within close proximity to the heart were seen in the emergency department. There were 104 exclusions: eight deaths on admission, 68 emergency/urgent thoracotomies, and 28 cardiac wounds discarded by other methods.

A total of 183 hemodynamically stable patients with penetrating trauma to thoracic box were taken to the OR for SPW; 176 (96.2%) were males. Median age was 25 years (IQR 20–32). Injury mechanism occurred in 99 (54.1%) patients with stab/knife and in 84 (45.9%) with firearms. Single wound injuries to the precordial region were observed in 131 (71.6%) patients; whereas single injuries in other location were observed in 13 (7.1%) patients; multiple injuries to the precordial region were observed in 39 (21.3%) patients. Median SBP on admission was 80 mm Hg (IQR 80–110). Clinical status on admission given by the PI was stable in 93 (50.8%) patients; there were 79 (43.2%) patients in whom SBP were <80 mm Hg but conscious and there were 11 (6.0%) patients at emergency department with treaty pulse, no measureable BP, and semiconscious. Any sign of pericardial tamponade was present on admission in 47 (25.7%) patients (Table 1).

There were 41 positive SPW (22.4%); all were males with median age of 24 (IQR, 20–29). A simple logistic regression indicated no statistically significant increased odds of positive SPW with increased age (OR 0.98, 95% CI 0.95–1.01, p = 0.382). The proportion of positive SPW in patients injured with stab/knife and firearms were 29.3% (29 patients) and 14.3% (12 patients), respectively. The odds of positive SPW among stab/knife wounds were significantly higher than among firearms (OR 2.48, 95% CI 1.17–5.25, p = 0.017). The proportions of positive SPW in patients with single precordial injuries and single injuries in other locations were 27.5% (36 patients) and 30.8% (four patients), respectively; combining those patients with single injuries the proportion of positive SPW was 27.8% (40 patients). The proportion of positive SPW in patients with multiple injuries was 2.6% (only 1 patient). The odds of positive SPW in patients with single injuries were significantly higher than in patients with multiple injuries (OR 14.61, 95% CI 1.9–110.0, p = 0.009). Median SBP in patients with positive and negative SPW were 80 mm Hg (IQR 70–85) and 95 mm Hg (IQR 80–110), respectively. The odds of positive SPW decreased significantly with increased SBP (OR 0.98, 95% CI 0.96–0.99, p = 0.005). The proportion of positive SPW was 12.9% (12 patients) among stable PI patients, 34.2% (27 patients) among patients with SBP <80 mm Hg and conscious, and 18.2% (two patients) among patients with treaty pulse, no measurable BP, and semiconscious. The odds of positive SPW in patients with stable PI were significantly lower than in a combined group of patients with instable PI (OR 0.31, 95% CI 0.14–0.65, p = 0.002). The proportion of positive SPW in patients with and without cardiac tamponade on admission was 53.2% (25 patients) and 11.8% (16 patients), respectively. The simple logistic regression indicated that the odds of positive SPW were higher when classic signs of pericardial tamponade were present (OR 8.52, 95% CI 3.92–18.4, p < 0.001) (Tables 1 and 2).

A multivariable logistic regression model was created in order to identify predictors independently associated with a positive SPW. Initially, predictors significantly associated with positive SPW in simple logistic regressions were included: stab/knife mechanism, single injury, SBP, stable PI, and any sing of pericardial tamponade. Using a stepwise manner, those variables with a p-value <0.1 were retained in the final model. The final stepwise multivariable logistic regression indicated that single injury (OR 12.99, 95% CI 1.6–102.7, p = 0.015) and any clinical sign of pericardial tamponade (OR 6.37, 95% CI 2.78–14.6, p < 0.001) were independently associated with positive SPW. Systolic blood pressure was not statistically associated with a positive systolic blood pressure (OR 0.98,

95% CI 0.97–1.00, p = 0.087) (Table 2). Additional analyses indicated that the odds of a positive SPW in patients with a single injury in other location was higher than in patients with a single injury in the precordial region, however, this difference did not reach statistical significance (OR 2.98, 95% CI 0.76–11.60, p = 0.115). The final regression model demonstrated adequate calibration (p = 0.659) and acceptable-to-excellent discrimination (AUC 0.817, 95% CI 0.747–0.886).

In patients with positive SPW, thoracotomy was performed in 40 (97.6%): cardiac injuries were found in 33, intrapericardial great vessel injuries in one, pericardial without cardiac or great vessel injuries in five, and lung injuries in one; thoracotomy was not performed in one (2.4%) patient. In patients with negative SPW, thoracotomy was performed in 45 (31.7%): cardiac injuries were found in one patient, lung injuries in 36, and other thoracic injuries in 8; thoracotomy was not performed in 97 (68.3%) patients. The sensibility and specificity of SPW for the diagnosis of cardiac injuries were 97.1 and 94.6%, the positive and negative likelihood ratios were 18.07 and 0.03, and the positive and negative predictive values were 80.5 and 99.3%, respectively.

DISCUSSION

In this study, 183 hemodynamic stable patients with penetrating injuries to the precordial region underwent SPW during a 3 years period. Stab/knife wounds, single injury, and the presence of any sign of pericardial tamponade were associated with higher rates of positive SPW. Conversely, SBP and stable PI were associated with lower rates of positive SPW. However, in the final multivariable logistic regression model, SBP and stable PI were not associated with positive SPW, whereas signs of pericardial tamponade and single injury were the only two independent predictors associated with a positive SPW.

Limitations must be acknowledged. The sample size needed in order to obtain reliable estimates from logistic regression models relies on the number of events per variable. In this study, sample variance is increased in the final estimates, thus, the magnitude of the associations might be underestimated. Perhaps, the magnitude of the prediction of a positive SPW of SBP and PI could be higher, recalling the attention of trauma care teams at emergency departments to work actively when patients present with these characteristics.

Diagnosis of occult cardiac injury could be difficult. The clinical manifestation of penetrating cardiac injuries ranges from complete hemodynamic stability to acute cardiovascular collapse; therefore, early recognition is vital to successful management.[6] Given the confined and nondistensible pericardial sac, tamponade adds significantly to the life-threatening risk of cardiac injury itself. In this study, clinical signs on admission of pericardial tamponade were significantly associated with increased odds of positive SPW, indicating that these could be the most important factor for the identification of occult cardiac injuries. Patients injured in the precordial region and presenting with any sign of pericardial tamponade could benefit from an immediate SPW procedure.

Patients with multiple penetrating injuries to the precordial region may present to the emergency department in extremis or in unstable condition. But, when they arrived in

stable condition represent a significant diagnostic and therapeutic challenge.[11] However, this study demonstrated that patients with single injuries to the precordial region or other anatomical location were associated with higher odds of positive SPW than patients with multiple injuries. Perhaps, patients with multiple injuries to the precordial region were taken to the OR for SPW because of increasing bias toward suspecting occult cardiac injuries. Nonetheless, these patients did not benefit from a SPW.

CONCLUSION

Systolic blood pressure and transient physiologic instability were not found as strong predictors of positive SPW. Emphasis on early recognition of signs of pericardial tamponade could be the most important factor for the identification of occult cardiac injuries. Patients with multiple injuries to the precordial region who reached the hospital may not benefit from a SPW. However, high level of awareness is important because the incidence of occult cardiac injuries is not negligible. In setting with low healthcare resources in which no other diagnostic tools are available, SPW continues to be a key diagnostic tool for occult cardiac injuries, in patients with penetrating injuries to the precordial region.

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Table 1:

Characteristics of hemodynamic stable patients with penetrating injuries to the precordial region who underwent a SPW

Characteristics	Total of patients (n = 183)	Positive SPW	p-value
Age (years)			
Mean (SD)	27.8 (11.4)	26.4 (10.5)	0.390
Median (IQR)	25 (20–32)	24 (20–29)	
Sex			
Males, n (%)	176 (96.2)	41 (23.3)	0.352
Females, n (%)	7 (3.8)	0 (0.0)	
Mechanism			
Stab/knife, n (%)	99 (54.1)	29 (29.3)	0.015
Firearm, n (%)	84 (45.9)	12 (14.3)	
Number and location of injuries			
Single precordial injury, n (%)	131 (71.6)	36 (27.5)	0.001
Single injury in other location, n (%)	13 (7.1)	4 (30.8)	
Multiple injuries, n (%)	39 (21.3)	1 (2.6)	
Systolic BP			
Mean (SD)	91.0 (28.4)	79.5 (25.6)	0.002
Median (IQR)	80 (80–110)	80 (70–85)	
Physiological index			
Stable, n (%)	93 (50.8)	12 (12.9)	0.003
Systolic BP <80 mm Hg and conscious, n (%)	79 (43.2)	27 (34.2)	
Thready pulse, no measurable BP, and semiconscious, n (%)	11 (6.0)	2 (18.2)	
Pericardial tamponade			
Yes, n (%)	47 (25.7)	25 (53.2)	<0.001
No, n (%)	136 (74.3)	16 (11.8)	
SPW			
Positive, n (%)	41 (22.4)	—	—

SPW: subxiphoid pericardial window; SD: standard deviation; IQR: interquartile range; BP: blood pressure.

Ellipses indicate not applicable

Table 2:

Predictors associated with a positive SPW in hemodynamic stable patients with penetrating injuries to the precordial region who underwent a SPW

	Unadjusted analysis[a]		Adjusted analysis[b]	
	OR (95% CI)	**p-value**	**OR (95% CI)**	**p-value**
Stab/knife mechanism	2.48 (1.17–5.25)	0.017	—	0.325
Single injuries	14.61 (1.9–110.0)	0.009	12.99 (1.6–102.7)	0.015
Systolic BP	0.98 (0.96–0.99)	0.005	0.98 (0.97–1.00)	0.087
Stable PI	0.31 (0.14–0.65)	0.002	—	0.642
Pericardial tamponade	8.52 (3.92–18.4)	<0.001	6.37 (2.78–14.6)	<0.001

SPW: Subxiphoid pericardial window; BP: blood pressure; PI: physiological index; OR: odds ratio; CI: confidence interval

[a]Simple logistic regression.

[b]Stepwise multivariable logistic regression model with backwards elimination, controlled for mechanism, number of injuries, systolic BP, PI, and pericardiac tamponade. Variables with p-value < 0.1 were retained in the model.

Ellipses indicate not applicable

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