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Research Article

Comparison of Percutaneous *Vs.* Surgical Drainage for Pericardial Effusion with Tamponade Physiology in a Single Institution Over One Year

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Abstract

Background: Pericardial effusion resulting in tamponade physiology is caused by a variety of pathologies and can be treated by either percutaneous or surgical drainage. The optimum modality for drainage of the various etiologies of pericardial effusion with tamponade physiology remains opaque. The aim of this paper is to better define the efficacy of both modalities.

Material and methods: All patients presenting at a single institution with pericardial effusion causing tamponade physiology in a consecutive 12-month period were reviewed with respect to type of drainage procedure, number of days a drain was in place, need for a subsequent drainage, ability to determine the etiology of the effusion and cost.

Results: A total of 20 patients underwent emergent pericardial drainage for suspected tamponade physiology in a 12-month period. Ten patients underwent percutaneous drainage and ten patients underwent surgical drainage. The median days of drain placement for the percutaneous patients was 4 days (range 2-5 days). The median duration of drain placement for surgical patients was 3 days (range 2-5 days). The difference in drain days was not statistically significant, $p > 0.2$. One patient from each group required a second drainage procedure. The etiology of the effusion was identified in nine patients in each group. The cost of percutaneous drainage was $1,357. The cost of surgical drainage ranged from $2295-$5357 depending upon the type of surgical procedure performed.

Conclusion: Percutaneous drainage resulted in similar duration of drain placement, ability to achieve the etiology of the effusion and freedom from second drainage procedures when compared with surgical drainage. Percutaneous drainage was associated with significantly lower cost than surgical drainage.

Introduction

Pericardial effusion resulting in tamponade physiology can be caused by a variety of etiologies [1,2]. Treatment for pericardial tamponade has included percutaneous drainage via pericardiocentesis and surgical drainage, traditionally via a subxyphoid window [3]. As technology has advanced both modalities have evolved with echocardiography and fluoroscopic guidance of percutaneous procedures [4] and video-assisted and robotic approaches for surgical procedures [5] improving their safety and efficacy. Previous reports recommend surgical drainage for suspected malignant etiologies of pericardial tamponade [1,6] and supportive infectious etiologies such as tuberculosis [7]. Pericardiocentesis has been advocated for most other etiologies; the European Society of Cardiology Working Group on Myocardial and Pericardial Diseases has created a scoring system and algorithm for the treatment of pericardial tamponade to better triage patients [8]. This scoring system assigns numerical value to the etiology, clinical presentation and imaging findings to better delineate patients in need of emergent drainage with a score of 6 suggestive of the need for urgent drainage. The scoring system recommends urgent surgical management for Type A aortic dissection, severe chest trauma and known cardiac or vessel perforation, Urgent pericardiocentesis is suggested for all other etiologies [8].

Imaging modalities such as echocardiography, fluoroscopy and computed tomography have become increasingly sophisticated and more readily available. Transthoracic Echocardiography (TTE) with its ability to be done expeditiously and inexpensively is the gold standard for the diagnosis of effusions resulting in tamponade physiology [2]. TTE findings associated with tamponade physiology include right ventricular diastolic collapse, inspiratory decrease and expiratory increase in pulmonary vein diastolic fluid forward flow and hepatic venous flow velocity showing expiratory decrease or reversal of diastolic flow are all suggestive of tamponade physiology [8]. Additionally, the pathological analysis of pericardial fluid has become more sophisticated with the ability to perform multiple tests

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on increasingly smaller volumes of fluid [9,10]. Pericardiocentesis is usually performed in the cardiac catherization laboratory but can be performed at the bedside in any location with the use of an imaging source such as echocardiography [1]. Pericardial window is a surgical procedure performed in the operating room under general anesthesia. The goals of both procedures are to relieve tamponade physiology, provide continuous drainage of the pericardial space, provide a diagnosis for the etiology of the effusion, and in some patients, provide a mechanism for treatment of the underlying cause of the effusion. In general, pericardiocentesis is performed by interventional cardiologists and interventional radiologists while subxyphoid windows are performed by cardiothoracic surgeons. Outside of codified institutional guidelines [8] patients are generally referred to one of the specialties based on availability and historic referral patterns. Contemporary literature is replete with reports relating the increasing incidence of patients presenting with tamponade physiology due to disparate etiologies such as iatrogenic injury from percutaneous coronary intervention, electrophysiological interventions and increasingly complex treatments for malignancy [11,12]. To better understand the efficacy of pericardiocentesis and surgical drainage for cardiac tamponade we reviewed patients presenting at our institution with pericardial effusions with tamponade physiology who presented over a consecutive 12-month period.

Materials and Methods

Our study reviewed patients were referred to either interventional cardiology or cardiothoracic surgery at our institution, Geisinger Community Medical Center, over 12 consecutive months. Patients with effusions from Type A dissections, obvious perforated vessel or cardiac chamber and significant chest trauma were excluded due to the high probability of surgical intervention for treatment. Although this is a retrospective review it should be noted that patients were referred prospectively to either specialty without consultation with the other service. Most procedures were performed without a team approach to ascertain whether percutaneous or surgical intervention was the preferred approach. Geisinger's Institutional Review Board provided approval for review of the patient's medical records and performance of the study. Twenty patients underwent drainage procedures for pericardial effusion with tamponade physiology. Suspected pericardial effusions were identified by either echocardiography or computed tomography and tamponade physiology was identified by established echocardiographic criteria (2,8). Ten patients underwent percutaneous drainage exclusively by interventional cardiology in the cardiac catherization laboratory with TTE and fluoroscopic guidance. Using a micropuncture technique to enter the pericardial space, a Teitel® pericardial catheter (Cook® Medical, Bloomington, IN) was placed using the Seldinger technique with the catheter left remaining in the pericardial space connected to a closed drainage system. Ten patients underwent surgical drainage eight of whom underwent a subxyphoid approach, one a video-assisted thoracoscopic (VATS) approach via the right chest and one a robotic (RATS) approach via the left chest (DaVinci Xi®, Intuitive Surgical®, Sunnyvale, CA). All surgical procedures were performed in the operating room under general anesthesia. The VATS and RATS approaches were chosen by the operating surgeon due to coexistent pleural space pathology needing simultaneous attention. All surgically drained patients left the operating room with a drain remaining in the pericardial space connected to a closed draining system. Following the initial drainage procedure patients convalesced in the surgical step-down unit with drain output recorded every shift. Drains were pulled when output was less than 25 ml per 8-hour shift. The duration of drain placement in days, the establishment of a diagnosis, the need for repeat pericardial drainage and the approximate cost of the drainage procedure were compared for each modality. Statistical analysis was conducted using the SPSS system version 10.0 (SPSS, Inc., Chicago, Ill., USA). Univariate comparison of categoric variables was done using the Student's t-test. Statistical differences were considered significant if the probability was 0.05 or less.

Results

The study included 20 patients, 10 in the percutaneous group and 10 in the surgical drainage group. Table 1 summarizes the comparison for the outcome data for the groups. The patients were accepted prospectively for their drainage procedure by either interventional cardiology or cardiovascular surgery depending upon which service the referring entity contacted, and availability of the respective specialist. There were no deaths and no significant morbidity due to the drainage procedure in either group. Among the ten patients undergoing percutaneous drainage the median duration of drain placement was 4 days. For the surgical group the corresponding number was 3 days. The difference did not achieve statistical significance, $p>0.2$. The etiology of the effusion was felt to be correctly delineated in nine patients in each group including malignancy in two patients in the percutaneous group and three patients in the surgical group. One patient from each group required repeat drainage, both at 48 hours, after their initial drainage procedure. The cost of the drainage procedure for the percutaneous group averaged $1,357. This included the cardiac catherization time and cost of the drainage catheter system. The cost of surgical drainage ranged from $2295-$5357 for operating room time and materials used. The lower end of the cost reflected charges for subxyphoid windows and the higher end for robotic drainage with the video-assisted thoracoscopic procedure in between the extremes. The costs include cardiac interventional catheter laboratory time and price of the drainage catheter for the percutaneous group and operating room cost and the drainage tube cost for the surgical group. Costs do not include professional fees for the interventional cardiologist for the percutaneous drainage patients or the surgeon and anesthesiologist fees for the surgical patients. Post-procedure costs for both groups of patients were similar as both group of patients recovered in the cardiac step-down unit while their catheters remained indwelling.

Discussions

Our study demonstrates that the results of percutaneous drainage and surgical drainage for patients presenting with cardiac tamponade are equivocal with respect to mortality, major morbidity, length of pericardial drainage days and ability to elucidate an etiology for the effusion. The need for a second drainage procedure was also similar for both groups. The cost of percutaneous drainage was significantly lower than surgical drainage with respect to hospital resource utilization. Patients presenting with pericardial effusion causing tamponade physiology as evidenced by systemic symptoms and signs of low cardiac output as well as echocardiographic evidence of right ventricular embarrassment are in need of emergent drainage. There are numerous causes of tamponade and as treatment options for patients with malignancies and other systemic illnesses grow more complex it is likely that incidence of patient's presenting with tamponade physiology will increase [13]. The treatment modality that can be accomplished most expeditiously with the least invasiveness provides the optimum therapy. It was previously felt that surgical drainage may have been preferable to percutaneous drainage for

Table 1: Comparison of Surgical and Percutaneous Drainage Patients.

Surgical Drainage Patients	Drain Duration (Days)	Pathological Cytology Diagnosis	Final Pathological Diagnosis	Need for Repeat Procedure	Comments
1	5	Blood Elements	Fibrinous Pericarditis	No	Subxyphoid Window
2	3	Atypical Cells	Sarcomatoid Carcinoma	No	VATS
3	3	Blood Elements	Not Delineated	No	Subxyphoid Window
4	3	Blood Elements	Fibrinous Pericarditis	No	Subxyphoid Window
5	2	Malignant Cells	Metastatic Breast Cancer	No	Subxyphoid Window
6	3	Malignant Cells	Metastatic Cancer	No	Subxyphoid Window
7	4	Mesothelial Cells	Fibrinous Pericarditis	No	Subxyphoid Window
8	2	Malignant Cells	Metastatic Lung Cancer	No	VATS
9	5	Mesothelial Cells	Fibrinous Pericarditis	No	Subxyphoid Window
10	2	Mesothelial Cells	Chronic Pericarditis	Yes; RATS done 2 days later	Subxyphoid Window
Percutaneous Drainage Patients					
1	5	Inflammatory Cells	Viral Pericarditis	No	Subxyphoid Pericardiocentesis
2	4	Mesothelial Cells	Fibrinous Pericarditis	No	Subxyphoid Pericardiocentesis
3	5	Malignant Cells	Metastatic Lung Cancer	No	Subxyphoid Pericardiocentesis
4	4	Mesothelial Cells	Fibrinous Pericarditis	No	Subxyphoid Pericardiocentesis
5	5	Mesothelial Cells	Metastatic Breast Cancer	No	Subxyphoid Pericardiocentesis
6	3	Mesothelial Cells	Fibrinous Pericarditis	No	Subxyphoid Pericardiocentesis
7	2	Malignant Cells	Metastatic Lung Cancer	Yes; VATS done 2 days later	Subxyphoid Pericardiocentesis
8	2	Malignant Cells	Metastatic Lung Cancer	No	Subxyphoid Pericardiocentesis
9	5	Blood Elements	Not Delineated	No	Subxyphoid Pericardiocentesis
10	3	Blood Elements	Fibrinous Pericarditis	No	Subxyphoid Pericardiocentesis

malignant and supportive pericardial effusions [1,7]. More recently it has been advocated percutaneous drainage be the first modality attempted for pericardial tamponade regardless of the presumed etiology [14]. The European Society of Cardiology working group on myocardial and pericardial diseases introduced a scoring system for cardiac tamponade in 2014 based on etiology, clinical presentation and imaging [8], Table 2. The score and corresponding algorithm recommend pericardiocentesis for all presentations except when there is a strong possibility of cardiac or great vessel perforation (aortic dissection, ventricular rupture, iatrogenic coronary artery perforation) as the cause of the tamponade. This strategy appears to be reflective of the recent literature [11-14]. The scores for our patients are shown in Table 3. Pericardiocentesis allows adequate drainage of the pericardial space and is not associated with prolonged drain placement when compared with surgical drainage [4,14]. Technological improvements in percutaneous interventions for tamponade have been developed allowing larger fenestrations to be made in the pericardium and separation between the pericardium and epicardium to be maximized [4]. Additionally, novel treatments, particularly for malignant etiologies of cardiac tamponade are being developed for delivery through percutaneously placed pericardial catheters [6]. Delineating the etiology of an effusion progressing to tamponade physiology was felt to be more probable through a surgical approach whereupon a tissue biopsy of the pericardium could be done to facilitate histological analysis [3]. As techniques in cytopathology have advanced with improved immunostaining capabilities [10] and increasingly sophisticated genetic analysis with Fluorescence In-Situ Hybridization (FISH), Polymerase Chain Reaction (PCR) and Next Generation Sequencing (NGS) the need for tissue has been minimized [9]. As demonstrated in our report, a significant amount of effusions progressing to tamponade are most likely multifactorial in nature and will demonstrate reactive mesothelial cells and/or blood products yielding a diagnosis of fibrinous pericarditis likely due to a systemic cause such as uremia or other non-malignant systemic state [15]. The significant cost savings associated with percutaneous drainage compared to surgical drainage also support it as the preferred first line modality. Further costs not contained in our analysis include the need for general anesthesia when drainage is performed in the operating room. As previously mentioned, there are several presentations of tamponade that should be performed in the operating room under general anesthesia including the possible need for control of bleeding from a suspected cardiac or great vessel perforation. Patient's presenting under these circumstances are generally readily identifiable and represent a different type of patient than those presenting with a more indolent source of tamponade. Also, patients that present with significant pathology in another anatomic area (such as a large pleural effusion) may be better served by surgical intervention whereupon both pathologies can be addressed simultaneously.

Finally, the minimal invasiveness associated with percutaneous intervention must be considered a significant benefit when compared to surgical intervention which involves an anesthetic and some form of incision no matter what approach. This clearly impacts recovery and pain control.

Table 2: The European Society of Cardiology Working Group on Myocardial and Pericardial Diseases Scoring System for Patients with Evidence of Pericardial Effusion with Tamponade Physiology.

Step 1. Score the Etiology	malignant disease	2
	tuberculosis	2
	recent radiotherapy	1
	recent viral infection	1
	recurrent effusion/previous pericardiocentesis	1
	chronic terminal renal failure	1
	immunodeficiency or immunosuppression	1
	hypo- or hyperthyroidism	-1
	systemic autoimmune disease	-1
Step 2. Score the Clinical Presentation	dyspnea/tachypnea	1
	orthopnea	3
	hypotension (SBP< 95 mmHg)	0.5
	progressive sinus tachycardia	1
	oliguria	1
	pulsus paradoxus > 10 mmHg	2
	pericardial chest pain	0.5
	pericardial friction rub	0.5
	rapid worsening of symptoms	2
	slow evolution of disease	-1
Step 3. Score the Imaging	cardiomegaly on CXR	1
	electrical alterans on ECG	0.5
	microvoltage in ECG	1
	circumferential effusion > 2 cm in diastole	3
	moderate effusion, 1-2 cm in diastole	1
	small effusion < 1cm in diastole	-1
	right atrial collapse	1
	IVC >2.5 cm; < 50% inspiratory collapse	1.5
	right ventricular collapse	1.5
	left atrial collapse	2
	mitral/tricuspid respiratory flow variations	1
	swinging heart	1
Step 4. Calculate the Cumulative Score from the sum of steps 1+2+3		
Score >6 recommend urgent pericardiocentesis if no contraindication		
Score <6 pericardiocentesis can be postponed for further workup		

Urgent surgical management for Type A dissection; ventricular free wall rupture after acute myocardial infarction; severe recent chest trauma; iatrogenic hemopericardium.

Table 3: European Society of Cardiology Working Group on Myocardial and Pericardial Diseases Tamponade Scores for surgical and percutaneous drainage patients.

Surgical Drainage Patients	Etiology Points	Presentation Points	Imaging Points	Total Points
1	1	2	3	6
2	2	2	4	8
3	1	2	2	5
4	1	3	2	6
5	2	2.5	3	7.5
6	2	3	3	8
7	1	2	3	6
8	2	3	3	8
9	1	2	3	6
10	0	2	4	6
Percutaneous Drainage Patients				
1	1	2	3	6
2	1	2	3	6
3	2	2	3	7
4	1	2	4	7
5	2	2	4	8
6	1	2	4	7
7	2	4	4	10
8	2	3	3	8
9	1	2	3	6
10	1	2	2	5

Conclusions

Our study has illustrated that percutaneous drainage for pericardial effusions with tamponade physiology has the same efficacy of surgical drainage with respect to ability to adequately drain the effusion, amount of days tube drainage is required, ability to diagnose the etiology of the effusion and need for secondary procedures. It does this at a significantly reduced cost. There are several deficiencies of our study: the small number of patients makes statistical evaluation difficult and the retrospective nature of the study may introduce bias into the drainage modality selected. These deficiencies could be remedied by a large prospective study. Despite these deficiencies we believe the study demonstrates that percutaneous drainage for pericardial effusions in patients presenting with tamponade physiology should be considered as the initial drainage modality except in those patients believed to have a perforation with active hemorrhage. Cardiovascular surgeons and interventional radiologists would benefit from acquiring the skills to perform the procedure.

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