Observational Study

Medicine®

OPEN

Effectiveness and outcomes of 2 therapeutic interventions for cardiac tamponade

A retrospective observational study

Hady Zgheib, MD[a], Cynthia Wakil, MD[a], Sami Shayya, MD[a], Rana Bachir, MPH[a], Mazen El Sayed, MD MPH[a,b,*]

Abstract

Pericardial effusions can either be drained by percutaneous pericardiocentesis (PCC) or by surgical pericardiotomy (SP), with limited evidence of superiority for the management of cardiac tamponade (CTa).

This study uses the US Nationwide Emergency Department Sample database to investigate the effectiveness of SP and PCC in patients with CTa in terms of clinical outcomes and healthcare costs.

Retrospective observational study conducted on the US Nationwide Emergency Department Sample 2014 dataset CTa patients. Descriptive and multivariate logistic regression analyses were done to assess the impact of different procedures (none, SP, PCC, SP, and PCC) on mortality.

A total of 10,410 CTa patients were included, of which 28.9% underwent no procedure, 32.9% underwent SP, 30.2% underwent PCC and 8.0% underwent SP and PCC. Mortality rates were highest in patients undergoing no procedure (22.3%) followed by PCC (15.0%), SP and PCC (11.5%), and then SP (9.6%) ($P < .001$). SP patients had longer length of stay (11.65 vs 8.16 days, $P < .001$) and higher total charges ($162,889.1 vs $100,802, $P < .001$) compared to PCC patients. Undergoing any procedure for CTa reduced the rate of mortality compared to no procedure with SP being the most effective (OR = 0.323, 95%CI 0.244-0.429), followed by SP & PCC (OR = 0.387, 95% CI 0.239–0.626), and then PCC (OR = 0.582, 95% CI 0.446–0.760).

Adult CTa patients treated with SP had lower mortality rates but longer length of stay and higher healthcare expenses. This SP associated benefit remained consistent across different subpopulations after stratifying by age and potential disease etiology.

Abbreviations: CTa = cardiac tamponade, NEDS = nationwide emergency department sample, PCC = percutaneous pericardiocentesis, SP = surgical pericardiotomy.

Keywords: cardiac tamponade, healthcare expenses, mortality, percutaneous pericardiocentesis, pericardial effusion, surgical pericardiotomy

1. Introduction

The heart is surrounded by a pericardial cavity which contains up to 50 mL of plasma ultrafiltration product.[1,2] Many pathological processes can infect, inflame or injure the pericardium and result in a pericardial effusion.[2] If the fluid accumulates rapidly or extensively in the pericardium, it can compress on the heart and impair cardiac filling, and lead to cardiac tamponade (CTa) and its potentially life-threatening hemodynamic changes.[2]

Pericardial effusions can either be drained by percutaneous pericardiocentesis (PCC) or by surgical pericardiotomy (SP).[3,4] As the most optimal procedure remains controversial,[5–9] the European Society of Cardiology still recommends both procedures.[10] Whereas PCC is less invasive, faster and done at the patient's bedside in the emergency room via percutaneous needle insertion, SP is done in the operating room and involves opening of the pericardium. In patients with CTa, studies comparing immediate results and long-term outcomes of patients who underwent PCC versus SP showed no significant difference in mortality and complications between both techniques.[3,11] Nevertheless, PCC was associated with incomplete fluid evacuation and more recurrence than SP.[9,11–13] In patients with malignant effusions, the current literature contains contradictory results regarding the preferred management technique. On one hand, SP was reported to be superior to PCC in preventing recurrence, providing symptom relief, and decreasing morbidity.[14–17] On the other hand, PCC was associated with fewer complications compared to SP.[18]

To date, limited evidence exists on the most optimal technique for the management of pericardial effusions. This study uses a US Emergency Department (ED) database to investigate the

Editor: Robert Chen.

The authors have no funding and conflicts of interest to disclose.

Supplemental Digital Content is available for this article.

The datasets generated during and/or analyzed during the current study are publicly available.

[a] Department of Emergency Medicine, [b] Emergency Medical Services and Prehospital Care Program, American University of Beirut Medical Center, Beirut, Lebanon.

[*] Correspondence: Mazen El Sayed, American University of Beirut Medical Center, Dept of Emergency Medicine, Riad El Solh Street, POBox 110236, Beirut, Lebanon 11072020 (e-mail: melsayed@aub.edu.lb).

How to cite this article: Zgheib H, Wakil C, Shayya S, Bachir R, El Sayed M. Effectiveness and outcomes of 2 therapeutic interventions for cardiac tamponade: a retrospective observational study. Medicine 2020;99:29(e21290).

Received: 19 November 2019 / Received in final form: 30 May 2020 / Accepted: 14 June 2020

http://dx.doi.org/10.1097/MD.0000000000021290

effectiveness of SP and PCC in adult patients with CTa. It compares SP and PCC in terms of clinical outcomes (mortality and length of stay) and healthcare costs.

2. Materials and methods

2.1. Study design and setting

This is a retrospective observational study of adult CTa patients in the Nationwide Emergency Department Sample (NEDS) 2014 public release dataset. In the US, NEDS is the largest all-payer ED database publically available through the Agency for Healthcare Research and Quality as part of the Healthcare Cost and Utilization Project. [dataset][20] The dataset contains medical and non-clinical data on 137,807,901 ED visits, weighted for national estimates, at 945 hospital-owned EDs consisting of a 20% stratified sample of hospital-based EDs across 33 participating US states and District of Columbia. [dataset][21] Hospitals are sampled according to census region, trauma center designation, location, ownership and teaching status for those sampled hospitals to be representative of hospitals throughout the US. The above stratification variables are used to statistically weigh the stratified sample of patients in order to examine national estimates.

The Institutional Review Board (IRB) at the American University of Beirut approved the use of this de-identified dataset for this study. HCUP Data Use Agreement (DUA) training course was completed and Nationwide Data Use Agreement signed by research participants. As per HCUP requirements to respect patient's rights and privacy, data variables for a sample of 10 or less participants was excluded.

2.2. Study population

A total of 137,807,901 weighted ED visits included in the NEDS 2014 dataset were screened for CTa to identify and include all adult patients presenting to EDs across US hospitals with CTa. No sample size calculation was conducted as all eligible patients for the objective of this study were selected from the NEDS database and included in the study sample. The ICD-9-CM code 423.3 was adopted to select CTa cases. To avoid any selection bias, all patients with an ICD-9-CM code of 423.3 in any of the 30 diagnoses present in NEDS 2014 were included in the study sample. To identify SP and PCC patients, respectively, Current Procedural Terminology (CPT) codes were screened for the ICD 9 CM codes "33020" and "33010", ED procedures were screened for the ICD 9 CM codes "3712" and "370" and inpatient procedures were screened for the ICD 9 CM codes "3712" and "370".

Patients were divided into 4 groups based on the procedure done: No procedure, PCC, SP and PCC and SP. Variables retrieved from the NEDS database included patient demographics and comorbidities, payment source, hospital characteristics, patient disposition, length of stay and healthcare expenses (see Appendix 1 which describes variable recoding process, http://links.lww.com/MD/E568).[21]

The primary outcome consisted of mortality rates (ED and inpatient). Secondary outcomes included healthcare costs and length of stay.

2.3. Statistical analysis

Statistical analyses were conducted using the Statistical Package for Social Sciences (IBM-SPSS, 24). Descriptive analysis was done with continuous variables presented as means with 95% confidence intervals (CI) and categorical variables presented as frequencies, percentages and 95% CI. No procedure was performed to handle missing data as all variables had less than 5% of data missing. The Rao-Scott Chi-Square test and a general linear model were used to compare the proportions of categorical and continuous variables respectively. All variables found to be significantly associated with the procedures were included in the multivariate analysis. A logistic regression model was conducted to assess the impact of different procedures (SP, PCC, and both) on patients' mortality after controlling for possible confounding factors. Additional stratification was done for age ($\leq$65, $\geq$66) and etiology (neoplasms) and adjusted odds ratios were calculated. A *P*-value $\leq$.05 was used for statistical significance.

3. Results

3.1. Characteristics of CTa patients

A total of 12,036 potentially eligible weighted adult ED visits with CTa were initially screened and 1,656 were excluded because of age less than 18 years, pregnancy complications, childbirth, puerperium, trauma or congenital anomalies. As such, a total of 10,410 weighted adult ED visits with CTa were included in our study. No procedure was done on 3011(28.9%) patients, 3425 (32.9%) underwent SP, 3140 (30.2%) had PCC and 834 (8.0%) underwent both procedures (Fig. 1). A slightly higher proportion of CTa patients consisted of males (52.6%) with mean age of 62 years (95% CI 61.52–62.64), residing in large central (31.5%) and large fringe (25.0%) metropolitan areas. Most of the study population was covered by Medicare (51.4%), private insurances (28.4%) or Medicaid (14.9%). They presented mostly to South (36%) and Midwest (25.4%) hospitals. Patients had associated endocrine, nutritional, metabolic or immunity disorders (80.3%), respiratory system diseases (71.6%), diseases of blood or blood-forming organs (54.3%), digestive system diseases (40.8%), neoplasms (30.7%) and infectious or parasitic diseases (25.2%). Overall mortality rate during hospital stay was 15.0% (Table 1).

When divided into 4 groups according to the treatment done, patients undergoing no procedure were of slightly higher age (63.56 years, 95% CI 62.50–64.61) when compared to those undergoing both procedures (59.5 years, 95% CI 57.62–61.42), SP and PCC patients had similar mean ages of 61.7 years (95% CIs of 60.76–62.71 and 60.67–62.75, respectively) (*P* –value of .002).

Only chronic condition indicators that were significantly different between groups were presented in Table 2. Patients who underwent SP had more endocrine, nutritional, metabolic and immunity disorders (83.3 vs 78.7%, $P=.026$), respiratory system diseases (77.0 vs 68.8%, $P<.001$), blood and blood-forming organs diseases (57.9% vs 49.9%, $P=.003$), digestive system diseases (42.8 vs 41.0%, $P<.001$) and neoplasms (34.8 vs 30.3%, $P<.001$).

3.2. Procedural and hospitalization outcomes

Mortality rates were significantly different between groups, with patients undergoing no procedure having the highest rates (22.3%) followed by those who underwent PCC (15.0%), both procedures (11.5%) then SP (9.6%) ($P<.001$).

Moreover, disposition of CTa patients significantly differed among groups. A higher proportion of patients undergoing no procedure were transferred to short-term hospitals or other

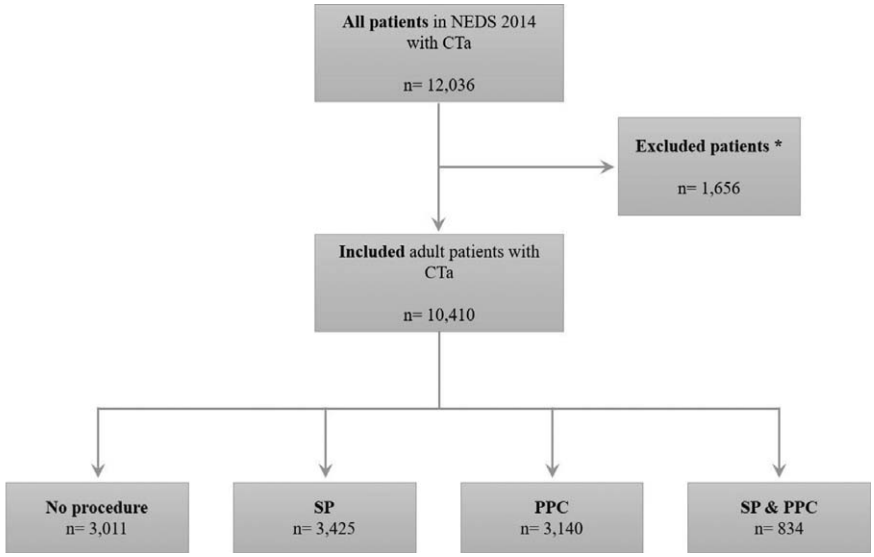

Figure 1. Flow chart of patients who met inclusion criteria for our study. *Patients < 18 years or with pregnancy complications, childbirth, puerperium, trauma or congenital anomalies. Numbers of ED visits presented are weighted for national estimates. CTa = cardiac tamponade, NEDS = Nationwide Emergency Department Sample, PCC = percutaneous pericardiocentesis, SP = surgical pericardiotomy.

facilities (42.0%) followed by those treated with PCC (26.2%), SP (21.4%) and both procedures (21.1%) ($P < .001$).

Patients who underwent SP had significantly longer length of stay compared to those who underwent PCC (11.65 vs 8.16 days, $P < .001$). They also had lower total ED charges but higher total ED and inpatient charges together ($P < .001$).

Results of logistic regression analysis showed that any procedure reduced mortality rate compared to no procedure with SP being the most effective (OR = 0.323, 95%CI 0.244–0.429), followed by SP and PCC (OR = 0.387, 95%CI 0.239–0.626) then PCC (0R = 0.582, 95%CI 0.446–0.760) (Table 3). This observed benefit for SP persisted in specific subpopulations stratified by age and etiology (neoplasm) (Table 4).

4. Discussion

CTa is a rapidly fatal medical emergency and the associated mortality risk depends on the speed of recognition and management of the condition, the treatment provided and the underlying cause. Mortality rates range from 13.3% in patients without malignancy to 76.5% for malignant effusions.[22] This observational study of over 10,000 CTa patients is the largest to date to evaluate different management techniques for CTa in terms of procedural and hospitalization outcomes. In this study, the overall mortality rate of CTa patients was of 15.0%.

SP was found to be superior to SP & PCC, which was superior to PCC alone in CTa patients. Overall mortality rates ranged from 9.6% (95%CI 8.0–11.6) in SP patients to 22.3% (95%CI 19.5–25.3) in patients undergoing no procedure. These observations are in line with those of a previous study by Petcu et al on the efficiency of SP vs PCC in 192 pericardial effusions associated with CTa where the in-hospital mortality rate was 15.1%.[11] SP and PCC patients included in our study had lower mortality rates, which could be related to different patients characteristics prior to adjusting for confounders including the presence of neoplasm. Indeed, post procedure survival is significantly influenced by the presence of a malignant etiology of the effusion.[11] Other studies, however, did not report variation in mortality rates according to procedure type. Horr et al examined 1281 patients requiring drainage of pericardial effusions without observed difference in mortality rates by procedure.[3] Reported mortality rates were also much lower than in our study where only 4.9% of patients who underwent PCC died compared to 6.1% of those who underwent surgical drainage. In previous observational studies, there were, however, unavoidable differences in patient profiles, effusion etiologies and hemodynamic stability in both treatment groups, and CTa was confirmed in only 71% of patients who underwent PCC and in 54% of those who underwent SP.[3]

In our observational study, despite the established perioperative risks of undergoing SP for CTa, SP was shown to offer a survival advantage compared to PCC. This significant mortality difference between both procedures cannot be merely explained by intra-procedural mortality, as per prior studies. The procedural complication rates related to SP have been reported to be up to 4% with sub-xiphoid drainage[8,23,24] and 12% with thoracoscopic windows.[25] On the other hand, major complications occurred in only 1 to 1.6% of PCC cases.[4] SP is an operative approach that offers definitive management but normally requires general anesthesia and intubation, both of which can have detrimental effects on CTa patients.[3] When compared to PCC patients, SP patients are more likely to suffer from hemodynamic instability within 48 hours of the procedure, yet they are less likely to have recurrence.[3,19,26] Nonetheless, isolated PCC provides instantaneous symptomatic relief at lower cost at the expense of not achieving complete fluid evacuation.[14] Given that clinical CTa is associated with effusion re-accumulation,[3] the higher mortality rates among patients who underwent PCC alone or both procedures might be attributed to higher re-accumulation rates after PCC though this was not directly measured in our study. According to a study by Gumrukcuoglu et al., no difference was noted in complication rates between PCC and SP and PCC; however, SP patients were less likely to develop complications compared to both PCC and SP and PCC groups.[27] It is also possible that patients who underwent

Table 1

Characteristics and hospitalization outcomes of cardiac tamponade patients.

Continuous Variables	Mean (95% CI)	Median	IQR (Q3–Q1)
Age (yr)	62.08 (61.52–62.64)	63	74–52

Categorical Variables	Frequency (N=10410)	Percentage (95% CI)
Gender		
Male	5480	52.6 (50.8–54.5)
Female	4930	47.4 (45.5–49.2)
Patient location: NCHS urban-rural code		
Large central metropolitan	3255	31.5 (30.3–32.8)
Large fringe metropolitan	2578	25.0 (23.8–26.3)
Medium metropolitan	2312	22.4 (21.3–23.5)
Small metropolitan	929	9.0 (8.1–10.0)
Micropolitan	781	7.6 (6.8–8.4)
Not metropolitan or micropolitan	462	4.5 (3.8–5.3)
Expected primary payer		
Medicare	5344	51.4 (49.5–53.2)
Medicaid	1550	14.9 (13.7–16.2)
Private including HMO	2956	28.4 (26.8–30.1)
Self-pay	292	2.8 (2.3–3.5)
No charge	16	0.2 (0.1–0.4)
Other	243	2.3 (1.8–2.9)
Hospital Region		
Northeast	1986	19.1
Midwest	2646	25.4
South	3751	36
West	2028	19.5
Chronic condition indicator	10286	98.8 (98.4–99.1)
Infectious and parasitic disease	2618	25.2 (23.6–26.8)
Neoplasms	3199	30.7 (29.0–32.5)
Endocrine, nutritional, metabolic and immunity disorders	8364	80.3 (78.8–81.8)
Blood and blood-forming organs diseases	5657	54.3 (52.5–56.2)
Mental disorders	3567	34.3 (32.5–36.0)
Diseases of the nervous system	3363	32.3 (30.6–34.1)
Diseases of the circulatory system	10410	100
Diseases of the respiratory system	7456	71.6 (69.9–73.3)
Diseases of the digestive system	4248	40.8 (39.0–42.6)
Diseases of the genitourinary system	5374	51.6 (49.8–53.5)
Diseases of the skin and subcutaneous tissue	818	7.9 (6.9–8.9)
Diseases of the musculoskeletal system	2453	23.6 (22.0–25.2)
Symptoms, signs, and ill-defined conditions	6173	59.3 (57.5–61.1)
Injury and poisoning	3130	30.1 (28.4–31.8)
Factors influencing health status and contact with health services	7932	76.2 (74.6–77.7)
Disposition of patient from ED		
Home	187	1.8 (1.4–2.4)
Transfer to short-term hospital & other facilities	270	2.6 (2.1–3.2)
Admitted	9777	93.9 (93.0–94.7)
Death	146	1.4 (1.0–1.9)
Other (Against medical advice & unknown destination)	30	0.3 (0.1–0.5)
Patient Disposition		
Routine & Home health care & Discharge alive, destination unknown	5533	56.6 (54.7–58.5)
Transfer to short-term hospital & other facilities	2768	28.3 (26.6–30.1)
Against medical advice	55	0.6 (0.3–0.9)
Died in hospital	1418	14.5 (13.2–15.9)
Died visit		
Did not die	8833	85.0 (83.6–86.2)
Died in ED/hospital	1564	15.0 (13.8–16.4)

Continuous Variables	Mean (95% CI)	Median	IQR (Q3–Q1)
Total ED charges ($)	3066.35 (2876.78–3255.91)	2093	3276–1494.5
Total ED and inpatient charges ($)	155687.95 (145750.84–165625.06)	87611	167935–44455
Length of stay	10.41 (9.90–10.93)	7	13–4

CI=confidence interval, ED=emergency department, HMO=health maintenance organization, IQR=interquartile range, NCHS=National Center for Health Statistics, Q1=first quartile, Q3=third quartile.

Table 2

Characteristics and hospitalization outcomes of cardiac tamponade patients after stratification by procedure.

	No procedure (N=3011)		SP (N=3425)		PCC (N=3140)		SP & PCC (N=834)		
Continuous variables	**Mean (95% CI)**		**Mean (95% CI)**		**Mean (95% CI)**		**Mean (95% CI)**		***P*-value**
Age (yr)	63.56 (62.50–64.61)		61.74 (60.76–62.71)		61.71 (60.67–62.75)		59.52 (57.62–61.42)		.002
Categorical Variables	**F**	**% (95% CI)**	**F**	**% (95% CI)**	**F**	**% (95% CI)**	**F**	**% (95% CI)**	
Gender									
Male	1611	53.5 (50.0–56.9)	1737	50.7 (47.6–53.9)	1666	53.1 (49.7–56.4)	466	55.9 (49.3–62.2)	.459
Female	1400	46.5 (43.1–50.0)	1688	49.3 (46.1–52.4)	1474	46.9 (43.6–50.3)	368	44.1 (37.8–50.7)	
Patient location: NCHS urban-rural code									
Large central metropolitan	807	27.1 (24.4–30.0)	1117	32.9 (30.3–35.7)	1037	33.3 (30.5–36.2)	294	35.3 (29.5–41.5)	<.001
Large fringe metropolitan	712	23.9 (21.3–26.7)	955	28.2 (25.6–30.9)	682	21.9 (19.4–24.6)	230	27.6 (22.3–33.6)	
Medium metropolitan	673	22.6 (20.0–25.4)	749	22.1 (19.7–24.7)	738	23.7 (21.1–26.5)	153	18.3 (13.7–24.1)	
Small metropolitan	338	11.3 (9.3–13.7)	238	7.0 (5.6–8.8)	295	9.5 (7.6–11.7)	58	7.0 (4.3–11.1)	
Micropolitan	276	9.3 (7.7–11.1)	184	5.4 (4.2–7.0)	257	8.3 (6.6–10.3)	64	7.7 (4.7–12.2)	
Not metropolitan or micropolitan	175	5.9 (4.5–7.5)	148	4.4 (3.2–5.9)	104	3.3 (2.3–4.8)	35	4.2 (2.2–8.0)	
Expected primary payer									
Medicare	1695	56.3 (52.8–59.7)	1773	51.9 (48.7–55.1)	1531	48.8 (45.4–52.1)	344	41.2 (35.0–47.8)	<.001
Medicaid	473	15.7 (13.3–18.4)	456	13.4 (11.4–15.6)	472	15.0 (12.8–17.6)	149	17.9 (13.3–23.5)	
Private including HMO	692	23.0 (20.1–26.1)	1013	29.7 (26.8–32.7)	989	31.5 (28.5–34.7)	262	31.4 (25.6–37.9)	
Self-pay	85	2.8 (1.9–4.1)	77	2.3 (1.5–3.5)	83	2.6 (1.7–4.0)	46	5.5 (3.2–9.5)	
Other & No charge	66	2.2 (1.4–3.4)	96	2.8 (1.9–4.0)	64	2.1 (1.3–3.3)	33	4.0 (2.1–7.2)	
Hospital Region									
Northeast	565	18.8 (16.7–21.0)	687	20.1 (18.1–22.2)	582	18.6 (16.5–20.8)	152	18.2 (13.8–23.6)	<.001
Midwest	826	27.5 (24.9–30.1)	751	21.9 (19.7–24.3)	856	27.3 (24.8–29.8)	212	25.4 (20.1–31.6)	
South	1057	35.1 (32.5–37.8)	1413	41.3 (38.8–43.7)	971	30.9 (28.4–33.6)	310	37.1 (31.4–43.2)	
West	563	18.7 (16.6–21.0)	574	16.8 (15.0–18.7)	730	23.2 (21.1–25.5)	161	19.3 (14.9–24.6)	
Chronic condition indicator	2950	98.0 (96.9–98.7)	3410	99.6 (98.9–99.8)	3103	98.8 (97.8–99.4)	823	98.7 (95.3–99.6)	.03
Neoplasms	684	22.7 (19.9–25.8)	1193	34.8 (31.9–37.9)	952	30.3 (27.3–33.5)	370	44.3 (37.9–50.9)	<.001
Endocrine, nutritional, metabolic and immunity disorders	2354	78.2 (75.2–80.9)	2854	83.3 (80.8–85.6)	2472	78.7 (75.9–81.3)	684	82.0 (76.3–86.5)	.026
Blood and blood-forming organs diseases	1612	53.6 (50.1–56.9)	1982	57.9 (54.7–61.0)	1567	49.9 (46.6–53.3)	495	59.4 (52.7–65.6)	.003
Diseases of the respiratory system	2001	66.4 (63.1–69.6)	2637	77.0 (74.2–79.6)	2162	68.8 (65.7–71.8)	658	78.8 (72.8–83.7)	<.001
Diseases of the digestive system	1035	34.4 (31.2–37.7)	1466	42.8 (39.7–46.0)	1286	41.0 (37.7–44.3)	461	55.2 (48.6–61.6)	<.001
Symptoms, signs, and ill-defined conditions	1919	63.7 (60.4–66.9)	1919	56.0 (52.9–59.2)	1860	59.2 (55.9–62.5)	474	56.8 (50.3–63.2)	.01
Injury and poisoning	1005	33.4 (30.3–36.6)	1070	31.2 (28.4–34.3)	836	26.6 (23.8–29.7)	218	26.1 (20.8–32.3)	.01
Factors influencing health status and contact with health services	2165	71.9 (68.7–74.9)	2675	78.1 (75.4–80.6)	2410	76.8 (73.8–79.5)	683	81.9 (76.2–86.4)	.003
Disposition of patient from hospital									
Routine and Home health care and Discharge alive, destination unknown & AMA	849	34.0 (30.5–37.7)	2194	64.4 (61.3–67.4)	1983	65.3 (62.0–68.5)	562	67.4 (60.9–73.2)	<.001
Transfer to short-term hospital and other facilities	1047	42.0 (38.3–45.7)	894	26.2 (23.5–29.2)	651	21.4 (18.8–24.4)	176	21.1 (16.3–26.9)	
Died in hospital	599	24.0 (20.9–27.4)	320	9.4 (7.7–11.3)	402	13.2 (11.1–15.7)	96	11.5 (7.9–16.6)	
Died visit									
Did not die	2337	77.7 (74.7–80.5)	3092	90.4 (88.4–92.0)	2666	85.0 (82.5–87.3)	738	88.5 (83.4–92.1)	<.001
Died in ED/hospital	669	22.3 (19.5–25.3)	329	9.6 (8.0–11.6)	469	15.0 (12.7–17.5)	96	11.5 (7.9–16.6)	
Categorical variables	**Mean (95% CI)**		**Mean (95% CI)**		**Mean (95% CI)**		**Mean (95% CI)**		***P*-value**
Total ED charges ($)	3672.93 (3320.69–4025.16)		2610.49 (2434.52–2786.46)		3201.86 (2698.36–3705.36)		2307.89 (2032.51–2583.28)		<.001
Total ED and inpatient charges ($)	219144.15 (186757.57–251530.74)		162889.14 (149380.66–176397.63)		100802.53 (92911.56–108693.50)		136232.98 (121923.74–150542.24)		<.001
Length of stay	11.20 (9.61–12.79)		11.65 (10.89–12.42)		8.16 (7.66–8.67)		11.19 (10.08–12.29)		<.001

AMA=against medical advice, CI=confidence interval, ED=emergency department, F=frequency, HMO=health maintenance organization, NCHS=National Center for Health Statistics, PCC=percutaneous pericardiocentesis, SP=surgical pericardiotomy.

Table 3

Multivariate logistic analysis of factors associated with hospital mortality among cardiac tamponade patients.

	Unadjusted		Adjusted*	
Procedure	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
SP	0.371 (0.284–0.485)	<.001	0.323 (0.244–0.429)	<.001
PCC	0.614 (0.478–0.790)	<.001	0.582 (0.446–0.760)	<.001
SP and PCC	0.456 (0.289–0.719)	<.001	0.387 (0.239–0.626)	<.001

CI=confidence interval, OR=odds ratio, PCC=percutaneous pericardiocentesis, SP=surgical pericardiotomy.
* Adjusted for age, patient location, primary expected payer, region of hospital and statistically significant variables of chronic condition indicators namely neoplasms, endocrine, nutritional and metabolic diseases and immunity disorders, diseases of blood and blood-forming organs, diseases of the respiratory system, diseases of the digestive system, symptoms, signs and ill-defined conditions, injury and poisoning and factors influencing health status and contact with health services.

PCC were poor surgical candidates with poorer prognosis to start with. In fact, 30.3% of PCC patients included in our study were oncology patients with malignant effusions, who tend to suffer from cachexia and multiple comorbidities.[3] Additionally, PCC is possibly preferred for terminal patients since it is less painful and ensures faster recovery, although not adequate as definitive management.

Moreover, in our study, both length of stay and total charges were significantly higher in CTa patients treated with SP as compared to PCC. Saltzman et al previously reported a significant difference of 9 days between SP and PCC.[28] Also, Zack et al reported significantly longer hospital stay and higher total charges for SP.[29]

According to the European Society of Cardiology, urgent SP rather than PCC is the treatment of choice for CTa in the event of hemopericardium associated with severe chest trauma, aortic dissection or ventricular free wall rupture in acute myocardial infarction as well as for purulent effusions in septic patients and loculated or posterior effusions that are not accessible percutaneously. PCC also has relative contraindications namely severe thrombocytopenia, uncorrected coagulopathy and anticoagulant therapy.[30] This heterogeneity between SP and PCC patients in etiology and location of the effusion causing CTa is not easily accounted for and usually renders comparison between surgical and nonsurgical management rather difficult. Additionally, in our study, patients with specific chronic diseases had significant differences in how they were managed in that those patients were treated with SP more often than with PCC. This shows that SP might be a better approach for chronic patients for long-term palliation. Sixty percent of pericardial effusions are associated with a known medical condition, the treatment of which would be that of the underlying disease.[4]

The choice of treatment should thus be individualized while taking into consideration the underlying etiology and the patient's prognosis, risks and success rates of SP and PCC, the institutional setting and local expertise available. In order to minimize risk and mortality associated with PCC, patients should be selected according to the underlying disease process, location and volume of the effusion as well as patient's coagulation status.[3,15]

Limitations of this study lie in its retrospective design and are related to unavailability of potentially confounding clinical variables including clinical severity scale, New York Heart Association class, criteria adopted for CTa diagnosis, vitals signs such as heart rate and blood pressure, etiology of effusion, platelets number at the time of procedure, SP technique and mortality cause.[3] Moreover, the NEDS database does not contain any data related to the patients' CTa characteristics, the medical management of patients who received no intervention or the criteria adopted for a patient to undergo both procedures. Available confounders including chronic medical condition indicators such as neoplasms that contribute to clinical severity were however adjusted for, and since all patients had CTa, it would be safe to assume that they had all comparable clinical severity. Lack of data on recurrence and follow up among transferred patients are other limitations that might have underestimated mortality rates in different groups. However, there is no reason to suspect that it affected a specific group more than another. Despite limitations, study findings reflective of outcomes across a large sample of US hospitals are expected to be consistent in other similar settings.

Table 4

Multivariate logistic regression analyses of factors associated with hospital mortality among cardiac tamponade patients stratified by age and neoplasms.

	Age				Neoplasms			
	≤ 65 yr		≥ 66 yr		No		Yes	
Procedure (No)	OR* (95% CI)	*P*-value	OR* (95% CI)	*P*-value	OR† (95% CI)	*P*-value	OR† (95% CI)	*P*-value
SP	0.320 (0.204–0.502)	<.001	0.333 (0.218–0.510)	<.001	0.343 (0.234–0.503)	<.001	0.257 (0.147–0.450)	<.001
PCC	0.707 (0.472–1.060)	.094	0.485 (0.327–0.721)	<.001	0.613 (0.439–0.857)	.004	0.488 (0.286–0.834)	.009
SP & PCC	0.349 (0.175–0.699)	.003	0.474 (0.222–1.010)	.053	0.485 (0.230–1.022)	.057	0.286 (0.128–0.640)	.002

CI=confidence interval, OR=odds ratio, PCC=percutaneous pericardiocentesis, SP=surgical pericardiotomy.
* Adjusted for patient location, primary expected payer, region of hospital and statistically significant variables of chronic condition indicators namely neoplasms, endocrine, nutritional and metabolic diseases and immunity disorders, diseases of blood and blood-forming organs, diseases of the respiratory system, diseases of the digestive system, symptoms, signs and ill-defined conditions, injury and poisoning and factors influencing health status and contact with health services.
† Adjusted for age, patient location, primary expected payer, region of hospital and statistically significant variables of chronic condition indicators namely endocrine, nutritional and metabolic diseases and immunity disorders, diseases of blood and blood-forming organs, diseases of the respiratory system, diseases of the digestive system, symptoms, signs and ill-defined conditions, injury and poisoning and factors influencing health status and contact with health services.

5. Conclusions

Adult CTa patients treated with SP had lower mortality rates but longer hospital stay and higher healthcare expenses. This SP associated benefit remained consistent across different subpopulations after stratifying by age and potential disease etiology. As each of the discussed interventions has benefits and risks, no single treatment plan can be universally and blindly adopted. Further areas of research should provide a detailed and structured mortality analysis that takes into account the effusion etiology, cause of death, clinical status and clinical risks of patients.

Author contributions

Conceptualization: Hady Zgheib, Cynthia Wakil, Sami Shayya, Mazen El Sayed.
Data curation: Hady Zgheib, Rana Bachir, Mazen El Sayed.
Formal analysis: Hady Zgheib, Cynthia Wakil, Sami Shayya, Rana Bachir, Mazen El Sayed.
Investigation: Hady Zgheib, Cynthia Wakil, Sami Shayya, Mazen El Sayed.
Methodology: Hady Zgheib, Cynthia Wakil, Sami Shayya, Rana Bachir, Mazen El Sayed.
Project administration: Hady Zgheib, Mazen El Sayed.
Resources: Hady Zgheib, Rana Bachir, Mazen El Sayed.
Software: Hady Zgheib, Rana Bachir, Mazen El Sayed.
Supervision: Hady Zgheib, Mazen El Sayed.
Validation: Hady Zgheib, Cynthia Wakil, Sami Shayya, Rana Bachir, Mazen El Sayed.
Visualization: Cynthia Wakil, Sami Shayya, Mazen El Sayed.
Writing – original draft: Hady Zgheib, Cynthia Wakil, Sami Shayya.
Writing – review & editing: Hady Zgheib, Cynthia Wakil, Sami Shayya, Mazen El Sayed.

References

[1] Vogiatzidis K, Zarogiannis SG, Aidonidis I, et al. Physiology of pericardial fluid production and drainage. Front Physiol 2015;6:62.
[2] Vakamudi S, Ho N, Cremer PC. Pericardial effusions: causes, diagnosis, and management. Prog Cardiovasc Dis 2017;59:380–8.
[3] Horr SE, Mentias A, Houghtaling PL, et al. Comparison of outcomes of pericardiocentesis versus surgical pericardial window in patients requiring drainage of pericardial effusions. Am J Cardiol 2017;120: 883–90.
[4] Imazio M, Adler Y. Management of pericardial effusion. Eur Heart J 2013;34:1186–97.
[5] Rafique AM, Patel N, Biner S, et al. Frequency of recurrence of pericardial tamponade in patients with extended versus nonextended pericardial catheter drainage. Am J Cardiol 2011;108:1820–5.
[6] Celik S, Lestuzzi C, Cervesato E, et al. Systemic chemotherapy in combination with pericardial window has better outcomes in malignant pericardial effusions. J Thorac Cardiovasc Surg 2014;148:2288–93.
[7] Tsang TS, Seward JB, Barnes ME, et al. Outcomes of primary and secondary treatment of pericardial effusion in patients with malignancy. Mayo Clin Proc 2000;75:248–53.
[8] Allen KB, Faber LP, Warren WH, et al. Pericardial effusion: subxiphoid pericardiostomy versus percutaneous catheter drainage. Ann Thorac Surg 1999;67:437–40.
[9] Laham RJ, Cohen DJ, Kuntz RE, et al. Pericardial effusion in patients with cancer: outcome with contemporary management strategies. Heart 1996;75:67–71.
[10] Adler Y, Charron P. The 2015 ESC Guidelines on the diagnosis and management of pericardial diseases. Eur Heart J 2015;36:2873–4.
[11] Petcu CP, Droc I. The efficiency of surgical subxiphoid pericardial drainage and percutaneous pericardial drainage in pericardial effusions associated with cardiac tamponade. Chirurgia (Bucur) 2013;108:226–33.
[12] Fiocco M, Krasna MJ. The management of malignant pleural and pericardial effusions. Hematol Oncol Clin North Am 1997;11:253–65.
[13] Chen EP, Miller JI. Modern approaches and use of surgical treatment for pericardial disease. Curr Cardiol Rep 2002;4:41–6.
[14] Jama GM, Scarci M, Bowden J, et al. Palliative treatment for symptomatic malignant pericardial effusiondagger. Interact Cardiovasc Thorac Surg 2014;19:1019–26.
[15] Labbe C, Tremblay L, Lacasse Y. Pericardiocentesis versus pericardiotomy for malignant pericardial effusion: a retrospective comparison. Curr Oncol 2015;22:412–6.
[16] Celermajer DS, Boyer MJ, Bailey BP, et al. Pericardiocentesis for symptomatic malignant pericardial effusion: a study of 36 patients. Med J Aust 1991;154:19–22.
[17] Ben-Horin S, Bank I, Guetta V, et al. Large symptomatic pericardial effusion as the presentation of unrecognized cancer: a study in 173 consecutive patients undergoing pericardiocentesis. Medicine (Baltimore) 2006;85:49–53.
[18] Patel N, Rafique AM, Eshaghian S, et al. Retrospective comparison of outcomes, diagnostic value, and complications of percutaneous prolonged drainage versus surgical pericardiotomy of pericardial effusion associated with malignancy. Am J Cardiol 2013;112:1235–9.
[19] Vaitkus PT, Herrmann HC, LeWinter MM. Treatment of malignant pericardial effusion. JAMA 1994;272:59–64.
[20] Healthcare Cost and Utilization Project. Introduction to the HCUP Nationwide Emergency Department Sample (NEDS). In: Agency for Healthcare Research and Quality R, MD., ed. 2014.
[21] Project HCaU. Nationwide Emergency Department Sample (NEDS) Overview. In: Agency for Healthcare Research and Quality R, MD., ed. 2014.
[22] Cornily JC, Pennec PY, Castellant P, et al. Cardiac tamponade in medical patients: a 10-year follow-up survey. Cardiology 2008;111:197–201.
[23] Van Trigt P, Douglas J, Smith PK, et al. A prospective trial of subxiphoid pericardiotomy in the diagnosis and treatment of large pericardial effusion. A follow-up report. Ann Surg 1993;218:777–82.
[24] McDonald JM, Meyers BF, Guthrie TJ, et al. Comparison of open subxiphoid pericardial drainage with percutaneous catheter drainage for symptomatic pericardial effusion. Ann Thorac Surg 2003;76:811–5. discussion 816.
[25] Geissbuhler K, Leiser A, Fuhrer J, et al. Video-assisted thoracoscopic pericardial fenestration for loculated or recurrent effusions. Eur J Cardiothorac Surg 1998;14:403–8.
[26] Cullinane CA, Paz IB, Smith D, et al. Prognostic factors in the surgical management of pericardial effusion in the patient with concurrent malignancy. Chest 2004;125:1328–34.
[27] Gumrukcuoglu HA, Odabasi D, Akdag S, et al. Management of cardiac tamponade: a comperative study between echo-guided pericardiocentesis and surgery-a report of 100 patients. Cardiol Res Pract 2011;2011: 197838.
[28] Saltzman AJ, Paz YE, Rene AG, et al. Comparison of surgical pericardial drainage with percutaneous catheter drainage for pericardial effusion. J Invasive Cardiol 2012;24:590–3.
[29] Joseph Zack C, Hermany P, McClurken J, et al. Comparative outcomes of pericardiocentesis versus surgical pericardiotomy in patients with chronic kidney disease and pericardial effusion in the united states. J Am Col Cardiol 2013;61(10 Supplement):E1280.
[30] Ristic AD, Imazio M, Adler Y, et al. Triage strategy for urgent management of cardiac tamponade: a position statement of the European Society of Cardiology Working Group on Myocardial and Pericardial Diseases. Eur Heart J 2014;35:2279–84.