Catheter ablation of accessory pathway: 14-year trends in utilization and complications in adults in the United States.

Jalaj Garg MD
Lehigh Valley Health Network, jalaj.garg@lvhn.org

Neeraj Shah MD
Lehigh Valley Health Network, Neeraj_N.Shah@lvhn.org

Parasuram Krishnamoorthy MD

Kathan Mehta

Babak Bozorgnia MD
Lehigh Valley Health Network, Babak.Bozorgnia@lvhn.org

See next page for additional authors

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Authors

Jalaj Garg MD; Neeraj Shah MD; Parasuram Krishnamoorthy MD; Kathan Mehta; Babak Bozorgnia MD; Noel G Boyle; Ronald S. Freudenberger MD; and Andrea Natale MD, FACC, FHRS, FESC

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Catheter ablation of accessory pathway: 14-year trends in utilization and complications in adults in the United States

Jalaj Garg [a,*,1], Neeraj Shah [a,1], Parasuram Krishnamoorthy [b], Kathan Mehta [c], Babak Bozorgnia [a], Noel G. Boyle [d], Ronald Freudenberger [a], Andrea Natale [e]

[a] Division of Cardiology, Lehigh Valley Health Network, Allentown, PA, United States
[b] Department of Cardiology, Einstein Healthcare Network, Philadelphia, PA, United States
[c] Department of Medicine, University of Pittsburgh, Pittsburgh, PA, United States
[d] UCLA Cardiac Arrhythmia Center, University of California, Los Angeles, CA, United States
[e] Texas Cardiac Arrhythmia Institute at St. David's Medical Center, Austin, TX, United States

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ABSTRACT

Background: The aim of this study was to determine the temporal trends in utilization of catheter ablation of accessory pathways in the United States.
Methods: All patients from the Nationwide Inpatient Sample (NIS) ≥18 years of age with a primary diagnosis of anomalous atrioventricular excitation syndrome (*International Classification of Diseases, Ninth Edition, Clinical Modification* [ICD-9-CM] code 426.7) were included in the study. Patients who underwent catheter ablation were identified using ICD-9-CM procedure code 37.34. Patients with a concomitant diagnosis of atrial fibrillation, atrial flutter, atrial tachycardia or ventricular arrhythmias were excluded from the analysis. Annual hospital volume was identified using unique hospital identification number and was divided into tertiles for further analysis.
Results: A total of 11,601 catheter ablations for anomalous atrioventricular excitation syndrome were studied from 1998 to 2011. The mean length of stay was 1.8 days (median 1 day). The utilization trends of accessory pathway ablation have steadily declined from 3.9 ablation procedures/million US population in 1998–1999 to 2.5 ablation procedures/million US population in 2010–2011. The second tertile (adjusted OR 0.41; 95% CI 0.20–0.83, p = 0.01) and third tertile (adjusted OR 0.39; 95% CI 0.18–0.85, p = 0.02) of hospital volume were associated with reduction in cardiac complications as compared to first tertile of hospital volume. Advanced age (OR 1.02, 95% CI 1.01–1.04, p = 0.002) was independent predictor of cardiac complications. There were no in-hospital deaths.
Conclusion: Despite decline in ablation trends, it still remains a relatively safe procedure associated with low morbidity and no mortality.

1. Introduction

The exact prevalence of accessory pathways associated with patient symptoms, also known as Wolff-Parkinson White (WPW) syndrome, is unknown but it is estimated to be between 0.068 and 0.17% [1]. A short refractory period of the accessory pathway may allow fast conduction to the ventricles resulting in rapid ventricular response. This could degenerate in ventricular fibrillation and cause sudden cardiac death with an estimated risk around 0.15% per patient-year [2,3]. In a prospective trial among an Italian pediatric population, the risk of life threatening tachycardia was 2.18% per patient-year and sudden cardiac death was estimated around 0.34% per patient-year [4].

It is estimated that approximately 65% of the patients with accessory pathway detected on the resting ECG are asymptomatic [5]. Also, since majority of patients do not have episodes of atrial fibrillation and/or paroxysmal supraventricular tachycardia, guidelines recommend catheter ablation as a Class I recommendation only for symptomatic patients (controversial in case of asymptomatic patients) [5].

The era of catheter ablation for the treatment of arrhythmias began in 1981 with the first atrioventricular junction ablation in patients with refractory atrial fibrillation and rapid ventricular response. Since then, direct current catheter ablation (which was associated with an

Abbreviations: WPW, Wolff-Parkinson White syndrome; NIS, Nationwide Inpatient Sample; HCUP, Healthcare Cost and Utilization Project; AHA, American Heart Association; NHDS, National Hospital Discharge Survey; ICD, International Classification of Diseases; PSI, Patient Safety Indicators; LOS, length of stay; NAPSE, North American Society of Pacing and Electrophysiology; MERFS, Multicenter European Radiofrequency Survey.

* Corresponding author at: Division of Cardiology, Lehigh Valley Health Network, 1250 S Cedar Crest Blvd, Allentown, PA 18103, United States.
E-mail address: garg.jalaj@yahoo.com (J. Garg).

[1] JG, NS have contributed equally for the paper.

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increased risk of barotrauma) has been replaced by radiofrequency catheter ablation resulting in increasing number of patients being safely treated for arrhythmias. Radiofrequency catheter ablation for accessory pathway has become the preferred treatment modality in patients with symptomatic accessory pathways with or without tachycardia [6–9]. Given paucity of data regarding the experience at the national level in United States, we designed the study to determine temporal trends of accessory pathway catheter ablation in the United States using a large national database.

2. Methods

2.1. Data source

We analyzed data from the Nationwide Inpatient Sample (NIS), provided by the Healthcare Cost and Utilization Project (HCUP) of the Agency for Healthcare Research and Quality, Rockville, MD from the years 1998–2011. This registry represents up to 8 million hospital stays from 1000 hospitals accounting for 20% of all inpatient admissions to non-federal hospitals in United States. It contains discharge-level data provided by states, which participate in HCUP. This database has been used previously to study trends and predictors of healthcare usage, patterns of major procedures, access, disparity of care, procedural adverse effect, hospitalization trends, charges, quality and outcomes [10–13]. Each individual hospitalization is de-identified and maintained in the NIS as a unique entry with 1 primary discharge diagnosis and ≤24 secondary diagnoses during that hospitalization. This registry also incorporates one primary procedure code and up to 15 secondary procedure codes. Each entry also carries information on demographic details, co-morbidities, hospitalization outcome and length of stay.

Annual data quality assessments of the Nationwide Inpatient Sample are performed, which guarantee the internal validity of this database. Furthermore, estimates from the NIS are compared to American Hospital Association (AHA) Annual Survey Database, the National Hospital Discharge Survey (NHDS) from the National Center for Health Statistics, and the MedPAR inpatient database from Centers of Medicare and Medicaid. Detailed reports regarding the data quality of NIS are available at the following website: http://www.hcup-us.ahrq.gov/db/nation/nis/nisrelatedreports.jsp.

2.2. Study design

Patients aged ≥18 years with a primary diagnosis of anomalous atrioventricular excitation syndrome (*International Classification of Diseases, Ninth Edition, Clinical Modification* [ICD-9-CM] code 426.7) were included in the study. Patients who underwent catheter ablation were identified using ICD-9-CM procedure code 37.34. Patients with concomitant atrial fibrillation, atrial flutter, atrial tachycardia and ventricular arrhythmias were excluded from the analysis (Supplementary Table 1).

2.3. Procedural complications

We used Patient Safety Indicators (PSIs) to identify preventable procedural complications, which have been established by the Agency for Healthcare Research and Quality to monitor preventable adverse events during hospitalization. These indicators are based on ICD-9-CM codes and Medicare severity Diagnosis-Related Groups and each PSI has specific inclusion and exclusion criteria. The PSI individual measure technical specifications, Version 4.4, March 2012 (http://www.qualityindicators.ahrq.gov/modules/PSI_TechSpec.aspx) was used to identify & define preventable complications viz. post-procedure acute renal failure requiring dialysis, post-procedure pulmonary embolism or deep vein thrombosis, post-procedure infectious complications which included postoperative sepsis & central venous catheter related bloodstream infections, iatrogenic pneumothorax, complications of anesthesia, and accidental puncture or laceration. Other procedure related complications were identified using ICD-9-CM codes (listed in Supplementary Table 1) in any of the secondary diagnoses fields. In order to prevent classification of a pre-existing condition (e.g. stroke or heart block) as a complication, cases with the ICD-9-CM code for a complication listed as the principal diagnosis (DX1) were excluded.

2.4. Hospital procedure volume

Hospital volume was computed using unique hospital identification number. The number of accessory pathway ablations performed by a particular hospital in a specific year was considered to be the annual hospital volume of that hospital for that year. Hospital volume was divided into tertile for further analysis. Hospitals performing 2 or less accessory pathway ablations annually were labeled as tertile I of annual hospital volume, hospitals performing >2 ablations but up to 5 ablations were characterized under annual hospital volume tertile II and any center performing 6 or more ablations was placed under annual hospital volume tertile III.

2.5. Utilization rates

United States Census data (http://www.census.gov/popest/data/index.html) was used to calculate for population estimates of all people aged 18 years or older in order to compute time trends in utilization rate from 1998 to 2011. Since NIS represents a 20% stratified random sample of US hospitals, the population at risk forming the denominator is 20% of US census population of adults ≥18 years age for any given year.

2.6. Statistical analysis

For all variables, weighted values of patient level observations were generated; using pre-specified weights in the NIS dataset, to produce a nationally representative estimate of US hospitalized patient population.

Differences between categorical variables were tested using Pearson chi-square test and differences between continuous variables were tested using either Student's *t*-test if the variables were normally distributed or Kruskal Wallis test if they were not normally distributed. p-Value of <0.05 was considered significant.

Multivariable logistic regression models were created incorporating covariates such as patient demographics, hospital volumes, hospital bed size, hospital region (east, midwest, south or west), hospital location (rural or urban), teaching hospital status, any complication, cardiac complications, vascular complications, cerebrovascular accident, postoperative hemorrhage and acute kidney injury. The following variables were included in the model to identify predictors of any complications and cardiac complications: patient demographics, hospital volumes, hospital bed size, hospital region (east, midwest, south or west), hospital location (rural or urban), and teaching hospital status.

Stata IC 13.0 (Stata-Corp, College Station, TX) was utilized for all analyses.

3. Results

A total of 11,601 accessory pathway catheter ablations were performed from 1998 to 2011. Table 1 demonstrates the demographic characteristics, in-hospital mortality, over all complications, cardiac complications, length of stay (LOS) stratified by hospital tertiles. The mean age in our study population was 37.3 ± 14.2 years, with women being older than men (38 years versus 37 years, $p = 0.02$). The mean length of stay was 1.8 days (median 1 day). Decreased LOS was observed in hospital tertile III 1.1 days as compared to 1.7 days in tertile II and 2.2 days in tertile I, $p < 0.001$. Table 1 demonstrates baseline demographics of patients with accessory pathway ablation.

3.1. Post-procedure complications incidence

Supplementary Table 1 illustrates all post-procedure complications and ICD-9 codes used to define all listed complications. Cardiac complications (2.3%) followed by vascular complications (1.39%) and postoperative hemorrhage (1.3%) were the most common complications after accessory pathway ablation. In addition, the incidence of complete heart block requiring permanent pacemaker and pericardial complications (composite of pericardial effusion and cardiac tamponade requiring pericardiocentesis) was 1.08% and 0.9% respectively. The overall rate of any complications was 4.36%, and cardiac complications was 2.3%; there was no in-hospital mortality. In addition, overall complication

Table 1
Baseline demographics of patients with accessory pathway ablation.

Variables[a]	Hospital tertile I	Hospital tertile I	Hospital tertile III	p value[b]
Age (years)	38.33 ± 0.50	37.39 ± 0.50	36.21 ± 0.52	0.02
Length of stay (days)	2.20 ± 0.09	1.69 ± 0.07	1.51 ± 0.06	<0.001
Mortality (%)	0	0	0	
Complete heart block requiring permanent pacemaker (%)	0.6	0.18	0.3	0.08
Cardiac tamponade (%)	0.26	0	0	0.005
Pericardiocentesis (%)	0.64	0.15	0	<0.001
Pericardial complications (%)	0.72	0.15	0	<0.001
Postoperative hemorrhage (%)	0.41	0.5	0.39	0.91
Hemorrhage requiring transfusion (%)	0	0	0	–
Acute kidney injury (%)	0.37	0.18	0	0.01
Thromboembolic event (%)	0.17	0	0.16	0.09
Vascular complications (%)	0.46	0.54	0.39	0.88
Any complications (%)	2.28	1.18	0.9	0.001
Any cardiac complications (%)	1.36	0.51	0.42	0.001

[a] Continuous variables are expressed as median (IQR). Categorical variables are expressed as %.
[b] Pearson's chi-square for categorical; linear regression for continuous variables.

rates were almost similar from the years 1998–1999 until 2010–2011 (3.4% versus 2.9%, respectively) (Supplementary Fig. 1).

Table 1 illustrates post-procedure complications stratified by hospital volumes. There was a lower incidence of any cardiac complications, pericardial complications, cardiac tamponade, and procedural interventions (pericardiocentesis) in hospitals with highest tertile of annual hospital volume (2.3% tertile I, 1.2% tertile II and 0.9% tertile III, $p < 0.001$) except for complete heart block requiring permanent pacemaker – (a trend towards decreased risks of complete heart block requiring permanent pacemaker (0.3%) in hospital tertile III was observed as compared to tertiles II and I; $p = 0.08$). Interestingly no pericardial complications (composite of cardiac tamponade or any intervention such as pericardiocentesis) were seen in hospital tertile III as compared to tertiles II and I ($p < 0.001$). Vascular complications were seen in 0.46% patients in hospital tertile I as compared to 0.54% patients in tertile II and 0.39% patients in tertile III ($p = 0.88$). There was no incidence of acute kidney injury in tertile III as compared to tertile II (0.18%) and tertile I (0.37%), $p = 0.01$.

3.2. Trends in utilization

Fig. 1 demonstrates that the utilization trends of catheter ablation for accessory pathway have steadily decreased from 3.9 ablation procedures per million US population in 1998–1999 to 2.5 ablation procedures per million US population in 2010–2011 (p for trend <0.001). From the figure, we also see that trends of accessory pathway ablation were almost similar until 2006–2007, following which there was steady decline in accessory pathway ablation.

Interestingly, in subgroup analysis for trends in ablation procedures, there was no reduction in ablation procedures in hospital tertile I (1.1 ablation procedures per million US population in 1998–1999 versus 1.2 ablation procedures per million US population in 2010–2011, p for trend <0.001) (Supplementary Fig. 2). Unlike tertile I of hospital volume, second tertile (1.5 ablation procedures per million US population in 1998–1999 to 0.7 ablation procedures per million US population in 2010–2011, p for trend <0.001) and third tertile of hospital volume (1.3 ablation procedures per million US population in 1998–1999 to 0.7 ablation procedures per million US population in 2010–2011, p for trend <0.001) demonstrated a steady decline accessory pathway ablation (Supplementary Figs. 3 and 4, respectively).

Table 2
Multimodal logistic regression analysis to determine predictors of any cardiac complications in patients with accessory pathway ablation.

Variables	Odd ratio[a]	p value
Age	1.02 (1.01–1.04)	0.003
Female	1.01 (0.58–1.76)	0.96
Hospital region[b]		
Midwest	1.84 (0.79–4.31)	0.15
South	1.38 (0.61–3.12)	0.44
West	1.66 (0.71–3.86)	0.25
Teaching hospital	1.13 (0.59–2.15)	0.70
Hospital volumes[c]		
Tertile II	0.41 (0.20–0.83)	0.01
Tertile III	0.39 (0.19–0.85)	0.02

[a] Model adjusted for age, sex, hospital region, hospital volumes and teaching hospital status.
[b] Hospital region east considered as referent.
[c] Hospital volume tertile 1 considered as referent.

3.3. Predictors of complications

Logistic regression demonstrated that second tertile (adjusted OR 0.41; 95% CI 0.20–0.83, $p = 0.01$) and third tertile (adjusted OR 0.39; 95% CI 0.18–0.85, $p = 0.02$) of hospital volume was associated with statistical reduction in cardiac complications as compared to first tertile of hospital volume. Hospital bed size, hospital location, hospital region, and teaching hospital status were not significant predictors of cardiac complication. Advanced age (OR 1.02, 95% CI 1.01–1.04, $p = 0.002$) was independent predictor of cardiac complications (Table 2). A similar trend was observed in overall complications (Supplementary Table 2).

3.4. Predictors of length of stay

Table 3 demonstrates predictors of increased LOS in patients with accessory pathway ablation. Advanced age (adjusted OR 1.01, 95% CI 1.01–1.02, $p < 0.001$) was associated with increased length of stay. The hospital tertile II and III (with tertile I as reference) and female sex were a statistical significant predictor of decreased LOS (adjusted OR of 0.59; 95% CI 0.48–0.74; adjusted OR 0.54; 95% CI 0.43–0.67, respectively, $p < 0.001$ for both) and adjusted OR 0.82 (95% CI 0.68–0.99, $p = 0.04$).

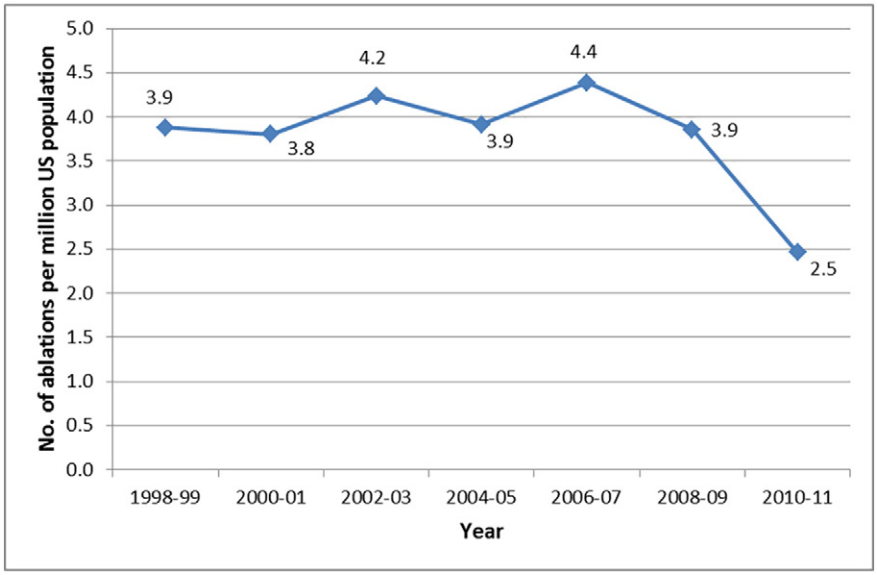

Fig. 1. Utilization trends of accessory pathway ablation per million US population from 1998–1999 to 2010–2011 (p for trend <0.001).

Table 3
Multimodal logistic regression analysis to determine predictors of increased length of stay in patients with accessory pathway ablation.

Variables	Odd ratio[a]	p value
Age	1.01 (1.01–1.02)	<0.001
Female	0.82 (0.68–0.99)	0.04
Postoperative hemorrhage	1.50 (0.11–20.37)	0.75
Cerebrovascular accident	0.49 (0.04–5.89)	0.57
Acute kidney injury	3.39 (0.43–26.88)	0.24
Vascular complication	0.49 (0.03–8.80)	0.62
Cardiac complication	1.20 (0.28–5.12)	0.80
Any complication	4.71 (1.09–20.24)	0.04
Hospital volumes[b]		
Tertile II	0.59 (0.48–0.74)	<0.001
Tertile III	0.54 (0.43–0.67)	<0.001

[a] Model adjusted for age, sex, complications and hospital volumes.
[b] Hospital volume tertile 1 considered as referent.

4. Discussion

With the use of a large national database in United States, we report trends in utilization and frequency of complications associated with accessory pathway ablations in the United States. The main findings of our analysis are as follows: (1) the utilization trends of catheter ablation for accessory pathway have steadily decreased from 3.9 ablation procedures per million US population in 1998–1999 to 2.5 ablation procedures per million US population in 2010–2011; (2) the frequency of overall complications was 4.36% and cardiac complications were 2.3%; (3) there were no in-hospital deaths; (4) third tertile of hospital volume (with first tertile as reference) was a significant predictor of decreased cardiac complications, overall complications and length of stay. This is the largest sample of accessory pathway ablations analyzed so far, with the use of data across the country over a large period of time.

Despite the success of accessory pathway ablation [8], our study demonstrates an initial increase in trends of accessory pathway ablation in the initial years from 1998–1999 until 2006–2007, followed by steady decline. The initial increasing trends in catheter ablation could have been due to re-do procedure in the pioneering years for electrophysiology in the same patient (although proving this is tough given inherit limitation of this database). Alongside there also has been decrease in the actual diagnosis and recognition of accessory pathway or anomalous atrioventricular excitation since 1993. This likely represents the initial population reservoir of accessory pathway patients in the first decade, regressing towards the annual number of new diagnoses. According to Agency for Healthcare Research and Quality, there were about 6964 hospital discharges with a principal diagnosis of anomalous atrioventricular excitation in 1993, which has decreased drastically to 2061 hospital discharges in the year 2011. Also, with increasing number of pediatric electrophysiologist and arrhythmia centers and success of ablation in the recent years, there has been a shift towards earlier ablation of patients with accessory pathway especially in children and, to a greater extent, adolescent patients. Thus, the decrease in accessory pathway ablation trends in adult patients over the last decade may have been partially or completely compensated by ablation of younger patients: data of which is not available in our study.

Multiple studies have reported complication rates following accessory pathway catheter ablation ranging from 2% to 4.4%, with almost all being conducted at high-volume centers [14,15]. Overall, cardiac complications were the most common acute complication seen in our patients undergoing accessory pathway ablation. In a study of North American Society of Pacing and Electrophysiology (NAPSE) in the year 2000 [16] and Multicenter European Radiofrequency Survey (MERFS) in 1993 [14], the reported incidences of cardiac complications were 2.44% and 2.7% respectively which is quite similar to that seen in our study (2.3% in our study). Studies have shown that the cardiac perforation with or without tamponade is one of the most common serious complications among all ablation procedures. This complication often develops due to the perforation of the right ventricle, coronary sinus, or left atrium. In our study, we report an overall frequency of pericardial complications of 0.9% as compared to other studies (1.4% in NAPSE (16) and 1.26% in MERFS study [14]) and no in-hospital mortality. Also, overall complications (0.9%) and cardiac complication rates (0.42%) were significantly lower in centers performing >5 ablation procedures (hospital tertile III) annually as compared to centers with <5 ablations annually. There were no procedure related pericardial complications in high volume centers in our study (i.e. >5 accessory pathway ablation annually). This may also explain the finding that there was decrease in the length of stay in high volume center in our study. This reflects increasing electrophysiological expertise and greater institutional experience consistent with a learning curve resulting in no pericardial complications and low incidence of overall complications and cardiac complications rates in high volume centers. Our study cohort is more representative of the real-world accessory pathway ablation cohort rather than a cohort from a single high volume center with highly skilled operators.

Our study has the limitation of being an observational study, where the possibility of selection bias and unmeasured confounders cannot be eliminated. NIS is an administrative database, and hence possibility of unrecognized miscoding of diagnostic and procedure codes cannot be excluded. We were also unable to assess the occurrence of late complications beyond the index hospitalization because NIS does not include any follow-up data and thus long-term morbidity and mortality cannot be estimated. Therefore, all data is cross sectional and the event rates (including cardiac complications or overall complications) reported refer to index hospitalization only. Furthermore, being an administrative database, the clinical details (location of accessory pathway) and relevant procedural protocol for anticoagulation, type of ablation catheter used (irrigated versus nonirrigated), fluoroscopy time, etc., was not available. In addition, we were unable to link accessory pathway ablation with rest of the ablation procedures performed in the same hospital. We recognize that overall ablation volumes would have been a better comprehensive predictor of hospital procedural experience. However, due to nature of this database, we can only calculate accessory pathway ablation volume at this time. However, these potential limitations may be partially equipoised by the large sample size and the ability to obtain nationwide estimates. Overall, results of our study provide us with reasonably accurate measure of procedural complications and trends of ablation over a period of decade in United States.

5. Conclusion

Despite decline in ablation trends (3.9 ablation procedures per million US population in 1998–1999 to 2.5 ablation procedures per million US population in 2010–2011), it still remains a safe procedure associated with a very low morbidity and no mortality. Also third tertile of hospital volume (with first tertile as reference) was associated with less cardiac complication, overall complications and was a significant predictor of decreased length of stay.

Conflict of interest

All the authors have no conflict of interest to disclose.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ijcard.2017.06.115.

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