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Type A acute aortic dissection repair during night time: is it safe?

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Abstract

Background Out-of-hours work is believed to lead to a higher complication rate and mortality after surgery. However, there is no data supporting this perception in type A acute aortic dissections (TAAD) repair. We present an observational study of prospectively collected data comparing operative outcomes and late survival of TAAD repair performed after hours versus regular daytime working hours.

Methods A total of 196 patients undergoing emergency TAAD repair (mean age 59 ± 13 years, range 18–81, F/M 57/139) were included in the final analysis. Patients were stratified as daytime between 7 AM and 7 PM ($n = 124$), and night time between 7 PM and 7 AM ($n = 72$). Inverse propensity score (PS) weighting for modelling causal effects was used to assess the effect of time procedure on outcomes of interest.

Results Overall 30-day mortality was 14.3% (28 patients). No significant differences were found between the night-time and day-time groups with regard to operative mortality (8.3% versus 17.3%; adjusted OR 0.35; 95%CI 0.12–1.04; $P = 0.06$), re-exploration (12.5% versus 9.7%; adjusted OR 2.09; 95%CI 0.72–6.07; $P = 0.18$) and neurological deficit (18.1% versus 16.9%; adjusted OR 0.91; 95%CI 0.33–2.54; $P = 0.87$). Long-term survival at mean 9 years follow-up was comparable between the two groups (adjusted log-rank $P = 0.28$).

Conclusions Night-time surgical repair of TAAD when compared with day-time repair does not seem to be associated with a greater risk of surgical complications, operative mortality and long-term mortality.

Keywords Aortic dissection · Type A aortic dissection · Repair of aortic dissection

Introduction

The causes of medical errors are often multifactorial; however, medical staff fatigue associated with delivering care outside daytime working hours is an important recognised driving factor [1–4].

It has been previously suggested that out-of-hours work leads to higher complication rate and mortality after surgery; surgeon fatigue, decreased availability of support staff and other logistical factors are believed to play an adverse role [3, 4]. However, recent large observational studies on non-cardiac procedures failed to demonstrate an adverse effect of night-time operations [5–7]. Moreover, very limited data are available regarding night-time work and adverse outcomes in cardiac surgery [8–10].

It is common practice in TAAD to proceed to surgery without delay even in the presence of clinical stability given the potential for catastrophic rupture [11]. This results in a large number of cases performed during night time. However, the perception that after-hours surgery may be associated with poorer outcomes remains and surgery is occasionally postponed to the following morning. To date, no previous study has investigated the impact of night-time operation in TADD repair.

Here, we present the results of an observational study comparing operative outcomes and late survival of TAAD repair performed during day-time and night-time working hours.

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Methods

Data sources and study population

The study was conducted according to the principles of the Declaration of Helsinki. The local ethics committee approved the study, and the requirement for individual patient consent was waived. Data prospectively collected were extracted from the institutional Patient Analysis and Tracking System (PATS).

Inclusion criteria We included patients who presented to our institution requiring repair of TAAD between 1992 and 2014 ($n = 209$). All patients irrespective of presence or absence of organ malperfusion were included in the study.

Exclusion criteria Patients with cardiogenic shock due to any cause and presenting with cardiac tamponade, or severe haemodynamic instability with or without pulmonary oedema were excluded ($n = 13$).

Sample size Thus, the study finally included a total of 196 patients (mean age 59 ± 13 years, range 18–81, female/male 57/139).

Patients were then stratified by operative time daytime was defined between 7 AM and 7 PM ($n = 124$) and night time between 7 PM and 7 AM ($n = 72$).

Definitions

Type A aortic dissection was classified according to the Stanford system where type A dissection involves the ascending aorta. Acute dissection was defined by onset of symptoms within 14 days of operative treatment. Malperfusion syndromes were defined according to symptoms from each arterial system and required clinical evidence of lack of blood flow to defined organ system. This included the following: cerebral/spinal malperfusion—stroke, paraplegia; cardiac malperfusion—electrocardiogram (ECG) changes, creatinine kinase (CK) or troponin elevation and myocardial dysfunction; ilio-femoral malperfusion—loss of pulses, sensory or motor function; renal malperfusion—creatinine elevation, lack of urine output; mesenteric malperfusion—abdominal tenderness, bowel ischemia, elevation of liver function tests. Evidence of dissection flap in branch vessels, either surgically or radiographically without symptoms of malperfusion, was not considered malperfusion syndrome.

Surgical procedure

Femoral arterial cannulation was the preferred choice for establishment of cardiopulmonary bypass (90%) with axillary cannulation and direct aortic cannultion was used in the remaining 10% of cases. Deep hypothermic circulatory arrest was used in all cases and selective antegrade cerebral perfusion in 22(11.2%) patients.

Outcomes of interest

Short-term outcomes investigated were 30-day mortality, postoperative neurological deficit, low output syndrome and re-exploration for bleeding. All-cause mortality was used as long-term outcome which represents the most robust and unbiased index in retrospective analysis, and it avoids inaccurate and biased documentation and clinical judgment. Information about death was obtained from the National General Register Office approximately 1 week after the event.

Statistical analysis

For baseline characteristics, variables are summarised as mean ± standard deviation for continuous variables and percentage for categorical variables. The chi-squared test was used to test unadjusted association between treatment variable and outcomes. Multiple imputation ($m = 3$) was used to address missing data. Rubin's method [12] was used to combine results from each of m imputed data sets.

Inverse propensity score weighting (IPSW) for modelling causal effects was used to assess the effect of night time versus day-time procedure on outcomes of interest [13]. For this purpose, a generalised boosted model (GBM) was implemented to estimate individual PS adjusting for 12 pre-treatment covariates including age, female gender, left ventricular ejection fraction < 50%, hypertension, peripheral vascular disease, previous cardiac surgery, malperfusion syndromes, aortic arch involvement, time from symptoms onset to surgery and time from diagnosis to surgery.

To estimate the average treatment effect on the treated (ATT), we gave each night-time case a weight of 1 and each day-time case a weight $wi = p(xi)/(1 - p(xi))$. The absolute standardised mean difference (ASMD) was used as a balance metric to summarise the difference between two univariate distributions of a single pre-treatment variable. A value ≥ 0.20 was considered an indicator of imbalance [14]. Effective sample size (ESS) in the weighted samples was calculated to account for the potential loss in precision from weighting. We then estimated the treatment effect with a weighted logistic regression model for operative outcomes and log-rank test for late mortality that contained only the treatment indicator (night time versus daytime). As sensitivity analysis, the effect of operative time on operative mortality was tested as a continuous variable in a PS-weighted adjusted spline analysis. R version 3.1.2 (2014-10-31) was used for all statistical analysis.

Results

Pre-treatment variables distribution and operative data

Table 1 summarises pre-treatment variable distribution between night-time versus day-time group. Overall, patients who underwent surgery during the daytime presented a higher risk profile including female gender, previous cardiac surgical procedure and hypertension. The incidence of malperfusion syndromes was not significantly different between the two groups. A trend towards a longer time from onset of symptoms to surgery and time from diagnosis to surgery was present in the day-time group. After inverse PS-weighting, the two groups were comparable for all pre-treatment variables. Operative data are summarised in Table 2. The two groups did not differ for any intraoperative variables analysed.

Effect of night time on outcomes

Crude operative outcomes and unadjusted PS-adjusted night-time effects are summarised in Table 3. Overall 30-day mortality was 14.3% (28 patients). No significant differences were found between the night-time and day-time groups with regard to operative outcomes investigated.

After a mean follow-up time of 7.9 ± 6.5 years (max 0–23), crude survival probability at 1, 5 and 15 was $89 \pm 4\%$ versus $81 \pm 4\%$, $84 \pm 4\%$ versus $77 \pm 4\%$, $70 \pm 6\%$ versus $57 \pm 5\%$ and $58 \pm 7\%$ versus $46 \pm 6\%$ in the night-time and day-time groups respectively (log-rank $P = 0.12$). In the propensity score–weighted sample, mean follow-up time was 9 years.

PS-weighted survival probability at 1, 5 and 15 was $89 \pm 4\%$ versus $78 \pm 17\%$, $84 \pm 4\%$ versus $75 \pm 18\%$, $70 \pm 6\%$ versus $58 \pm 23\%$ and $58 \pm 7\%$ versus $51 \pm 26\%$ in the night-time and day-time groups respectively (log-rank $P = 0.28$).

Effect of operative time as continuous variable on mortality

In a PS-weighted spline analysis, operative time considered a continuous variable was not significantly associated with operative mortality ($P = 0.28$) but hourly variations in mortality during the 24-h period were noted.

Discussion

To our knowledge, this analysis represents the only study to date investigating the association of operative time of day with outcomes in type A acute aortic dissection repair. Night-time repair did not increase operative mortality or postoperative complications including re-exploration, incidence of postoperative neurologic deficit or low output syndrome. Furthermore, Night-time operations did not affect late survival. Surprisingly, hourly variations in mortality during the 24-h period were noted with a trend towards a lower mortality rate during the night hours. This trend might be partially related to the residual imbalance regarding the prolonged time from symptom onset to surgery in the day-time group. Such a delay might be responsible for prolonged organ malperfusion thus leading to poorer operative outcomes.

Table 1 Pre-treatment variables distribution in the unweighted and propensity score–weighted groups

	unw night time $N = 72$	unw daytime $N = 125$	unw ASMD	unw P	PS-w night time $N = 55$	PS-w daytime $N = 124$	PS-w ASMD	PS-w P
Age (years)	60 ± 13	58 ± 14	0.17	0.26	60 ± 13	60 ± 11	0.01	0.96
Female	24%	32%	− 0.20	0.19	24%	28%	− 0.10	0.58
Arch involvement	26%	23%	0.09	0.55	26%	24%	0.06	0.73
Previous cardiac surgery	4%	10%	− 0.27	0.12	4%	5%	− 0.03	0.87
LVEF < 50%	8%	10%	− 0.08	0.61	8%	8%	− 0.00	0.98
Vascular disease	8%	7%	0.04	0.79	8%	6%	0.08	0.62
Hypertension	53%	64%	− 0.23	0.11	53%	54%	− 0.03	0.85
Marfan diagnosis	6%	4%	0.07	0.64	6%	1%	0.18	0.16
Cerebral malperfusion	10%	10%	0.00	0.99	10%	7%	0.07	0.63
Renal malperfusion	4%	6%	− 0.07	0.64	4%	4%	0.01	0.92
Mesenteric malperfusion	4%	3%	0.05	0.74	4%	2%	0.10	0.50
Ilio-femoral malperfusion	10%	12%	− 0.08	0.60	10%	10%	− 0.02	0.90
Symptoms to surgery (h)	19 ± 21	22 ± 19	− 0.14	0.31	19 ± 21	18 ± 7	0.04	0.80
Diagnosis to surgery (h)	7 ± 6	9 ± 9	− 0.35	0.06	6 ± 6	7 ± 7	− 0.10	0.63

unw, unweighted; *PS-w*, propensity score weighted; *ASMD*, absolute standardised mean difference; *LVEF*, left ventricular ejection fraction

Table 2 Operative data

	Night-time group	Day-time group	P
Aortic valve replacement %	38.9%	36.3%	0.8
Root replacement %	30.6%	21.8%	0.2
Arch replacement %	8.3%	11.3%	0.7
Cardio-pulmonary bypass time (min)	173	174	0.9
Cross clamp time (min)	92	84	0.2
Selective antegrade cerebral perfusion %	8.7%	11.8%	0.8

Although specific information regarding the reasons for prolonged time from symptoms onset to surgery in the day-time group were not available, we can speculate that this might be partially explained by delayed operations for night-time admissions. In addition, during day-time operative rooms are usually occupied with elective surgeries which may further delay the emergency case. Finally, we found a higher prevalence of previous cardiac operation in the day-time group. Previous sternotomy is commonly believed to be a protective factor for imminent rupture, and these cases are more likely to be postponed to the following morning. On the other hand, previous sternotomy can affect operative outcomes with its relative technical complexity.

Although operative mortality is ultimately the most important outcome measure, a detailed examination of secondary outcomes is crucial to understanding the potential adverse effects if any, associated with night-time surgery repair. We also found that the incidence of postoperative complications was comparable between the two groups with only a mild increase in re-exploration for bleeding in patients undergoing repair at night. Postoperative bleeding requiring reoperation is not an uncommon complication after surgery for aortic dissection.

Patients presenting with cardiogenic shock due to any reason are deemed to have worse prognosis, and immediate surgical intervention is recommended. However, in the relatively stable patients' concerns have been raised about operating out of hours. Theoretically, surgical fatigue could lead to careless technique, resulting in additional bleeding requiring reoperation. However, the absolute difference we observed was small and unlikely to be of clinical significance.

Acute aortic dissection repair is associated with increased technical complexity and mortality rate. In this context, the potential reduction in performance during night time secondary to fatigue, intraoperative shift changes, technical lapses and decreased situational awareness is anticipated to have an impact on operative outcomes [1–4]. This perception occasionally leads surgeons to delay surgery to the following morning in particular in cases of clinical stability. Contrary to the common belief, we found that operating at night was not associated with worse outcome following TAAD repair. Thus, not only in cases of haemodynamic instability, where emergent intervention is important, but also in patients who are relatively stable, an early surgical repair is recommended. This approach is also supported by the reported mortality rate of 1 to 2% per hour immediately after symptom onset in historical untreated patients [11] and based on the assumption that prolonged period of organ malperfusion can affect operative outcomes.

Our results are supported by other recent reports on operative time and surgical outcomes. Despite that extended work shifts inevitably lead to sleep deprivation and fatigue and may potentially result in reduced performance as reported for in-hospital cardiac arrest [2], the literature on the impact of night-time operation on surgical outcomes and performance gives conflicting results [3, 10]. A recent report from the US National Trauma Data Bank [5] (2007 to 2010) on 16,096 patients and 15,109 patients who underwent an exploratory laparotomy in the night– time and day–time, respectively, found no difference in the risk-adjusted mortality rate between the two groups. For thoracic organ transplantation, the United Network for Organ Sharing (UNOS) database cohort study including more than 27,000 heart and lung transplant

Table 3 Operative outcomes

	Night time	Daytime	uw OR[95%CI]	uw P	PS-wOR[95%CI]	PS-w P
Mortality	8.3%	17.3%	0.40[0.15–1.04]	0.08	0.35[0.12–1.04]	0.06
Re-exploration	12.5%	9.7%	1.33[0.52–3.32]	0.54	2.09[0.72–6.07]	0.18
ND	18.1%	16.9%	1.08[0.49 2.29]	0.84	0.91[0.33–2.54]	0.87
LOS	15.3%	16.9%	0.88[0.38–1.93]	0.76	0.93[0.72–6.07]	0.88

unw, unweighted; *PS-w*, propensity score weighted; *OR*, odds ratio; *CI*, confidence interval; *ND*, neurological deficit; *LOS*, low output syndrome

recipients also did not reveal any significant association between night-time heart or lung transplantation and 1-year mortality [6]. An international prospective observational study on 11,290 patients from 28 European countries undergoing urgent non-cardiac surgery did not identify any relationship with the time of day at which the procedure was performed [7]. In addition, three available studies reporting on coronary artery bypass graft and valve surgery [8–10] found no significant differences in mortality or intraoperative complications in patients operated on by sleep-deprived versus non-sleep-deprived surgeons. Therefore, the common belief that surgeons perform at their best during daytime rather than in the middle of night does not seem to be consistently supported by current evidence.

Limitations

As with all observational studies, a caveat of our study is the selection bias introduced by not randomizing patients to the 2 operating time groups. We have tried to minimize this bias by propensity-weighting patients using the set of patient risk factors available in our registry. Nevertheless, a remaining threat to selection bias is unmeasured factors in particular the information regarding reasons for the prolonged time from symptoms onset to surgery in the day-time group (surgeon preference, clinical features). Furthermore, we were unable to account for surgeon-level variables such as experience, fatigue, time since last sleep or length of shift. Finally, given the relatively small sample size, analysis on hourly variations in mortality was not conclusive; studies with larger sample sizes and longer follow-up periods are needed to confirm these findings.

Conclusions

In summary, contrary to the common perception, Night-time TAAD repair was not associated with a greater risk of operative morbidity and long-term mortality than day-time repair. According to our results, it seems, therefore, reasonable to suggest that TAAD repair procedures should be performed as emergency operation regardless of the time of day. Further larger studies are required to draw definitive conclusions.

Compliance with ethical standards

The study was conducted according to the principles of the Declaration of Helsinki. The local ethics committee approved the study, and the study being a retrospective analysis of data, formal requirement for individual patient consent was waived.

Conflict of interest   The authors declare that they have no conflict of interest.

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