Cardiology in the Young

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Alpha-blockade during congenital heart surgery admissions: analysis from national database

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Abstract

Introduction: The effects of alpha-blockade on haemodynamics during and following congenital heart surgery are well documented, but data on patient outcomes, mortality, and hospital charges are limited. The purpose of this study was to characterise the use of alpha-blockade during congenital heart surgery admissions and to determine its association with common clinical outcomes. Materials and Methods: A cross-sectional study was conducted using the Pediatric Health Information System database. De-identified data for patients under 18 years of age with a cardiac diagnosis who underwent congenital heart surgery were obtained from 2004 to 2015. Patients were subdivided on the basis of receiving alpha-blockade with either phenoxybenzamine or phentolamine during admission or not. Continuous and categorical variables were analysed using Mann–Whitney U-tests and Fisher exact tests, respectively. Characteristics between subgroups were compared using univariate analysis. Regression analyses were conducted to determine the impact of alpha-blockade on ICU length of stay, hospital length of stay, billed charges, and mortality. Results: Of the 81,313 admissions, 4309 (5.3%) utilised alpha-blockade. Phentolamine was utilised in 4290 admissions. In univariate analysis, ICU length of stay, total length of stay, inpatient mortality, and billed charges were all significantly higher in the alpha-blockade admissions. However, regression analyses demonstrated that other factors were behind these increased. Alpha-blockade was significantly, independently associated with a 1.5 days reduction in ICU length of stay ($p < 0.01$) and a 3.5 days reduction in total length of stay ($p < 0.01$). Alpha-blockade was significantly, independently associated with a reduction in mortality (odds ratio 0.8, 95% confidence interval 0.7–0.9). Alpha-blockade was not independently associated with any significant change in billed charges. Conclusions: Alpha-blockade is used in a subset of paediatric cardiac surgeries and is independently associated with significant reductions in ICU length of stay, hospital length of stay, and mortality without significantly altering billed charges.

Introduction

Alpha adrenergic receptors are G-coupled protein receptors that are divided into two subgroups: Alpha 1 and Alpha 2. Both Alpha 1 and Alpha 2 receptors share similar vasoconstrictive effects when stimulated and vasodilatory effects when inhibited. Use of alpha-blockade, particularly in paediatric hypothermic cardiopulmonary bypass, is associated with a more rapid and uniform body cooling and rewarming that may be associated with enhanced peripheral and cerebral perfusion during cardiopulmonary bypass.[1] In the ICU, alpha-blockade allows for augmentation of peri-operative and post-operative haemodynamics by increasing cardiac output while decreasing systemic vascular resistance. Commonly used Alpha antagonists include phenoxybenzamine and phentolamine. Phenoxybenzamine has been shown to improve systemic oxygen delivery and improved survival in patients with hypoplastic left heart syndrome whom underwent the Norwood procedure.[2] The use of phentolamine has been associated with limited anaerobic metabolism during cardiopulmonary bypass when compared to controls as evidenced by lower lactate levels and higher systemic oxygen delivery.[4]

Given the limited yet promising previously published data regarding alpha-blockade during or after congenital heart surgery, the following study was conducted to help clarify the frequency of use of alpha-blockade, the population it is used in, and its effects on admission characteristics. The purpose of these analyses was to use data from a large national database to answer the following questions: characterise the choice of alpha-blockade and the frequency of use of alpha-blockade in congenital heart surgery admissions and determine the effect of alpha-blockade on length of stay in the ICU, total hospital length stay, mortality in congenital heart surgery admissions and hospital charges.

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Methods

As this study utilised de-identified data from a national database, no consents were obtained by the authors of this study. This study is in concordance with the Helsinki declaration and the World Health Medical Association Declaration of Taipei on Ethical Considerations Regarding Health Databases and Biobanks.

Pediatric Health Information System database

Data for this study were obtained from the Pediatric Health Information System database. Pediatric Health Information System is an administrative and billing database that contains inpatient, emergency department, ambulatory surgery, and observation data from not-for-profit, tertiary care paediatric hospitals in the USA. The 53 hospitals that contribute data to Pediatric Health Information System are affiliated with the Children's Hospital Association (Lenexa, KS), a business alliance of children's hospitals. Data quality and reliability are assured through a joint effort between the Children's Hospital Association and participating hospitals. For the purposes of external benchmarking, participating hospitals provide discharge/encounter data including demographics, diagnoses, procedures, and charges. Data are de-identified at the time of data submission, and data are subjected to a number of reliability and validity checks before being included in the database.

Admission identification

Pediatric Health Information System database data from 2004 to 2015 were utilised for this study.

Firstly, admissions with cardiac diagnoses were identified. Supplementary Table 1 outlines the cardiac diagnoses which ultimately were eligible for consideration. Of these admissions, those with cardiac surgery were identified. Thus, the inclusion criteria for admissions for this study were paediatric admissions under 18 years of age; a cardiac diagnosis; and congenital heart surgery. Any admissions not meeting these criteria were excluded. From this point forward, the word "admission" will be used to refer to admissions meeting these inclusion criteria unless otherwise specified.

The admissions were then separated into two groups: those without use of alpha-blockade and those with use of alpha-blockade. Alpha-blockade was defined as use of either phenoxybenzamine or phentolamine. Timing of alpha-blockade could not be determined from the database. Thus, the alpha-blockade may have occurred peri-operatively or post-operatively.

Admission characteristics

Several data points were captured for each of the included admissions. Age of admission, gender, and year of admission were captured for all admissions. Length of stay, billed charges, and inpatient mortality were also recorded for all admissions. Any use of "mortality" from here on after will refer to inpatient mortality during the admission of interest.

The presence of specific congenital malformations of the heart was captured using the ICD-9 codes outlined in Supplementary Table 1. The presence of specific cardiac surgeries during the admissions was also captured using the ICD-9 codes outlined in Supplementary Table 1.

The presence or absence of the following comorbidities was recorded as provided by the database: heart failure, tachyarrhythmia, bradyarrhythmia, acute kidney injury, pulmonary hypertension, hypothyroidism, and the presence of syndromes.

Severity of illness measures includes the comorbidities listed above as well as absolute number of different vasoactive agents used during the admission. Use of steroids was also recorded in part to help assess severity of illness, although the indication for steroids cannot be discerned from the database. Clinical or laboratory data such as near infrared spectroscopy, serum lactate, or venous saturation were not available for use.

Statistical Analyses

Continuous variables were described as median and range, while categorical variables were described as absolute frequency and percentage. Analyses of continuous variables across groups were conducted using a Mann–Whitney U-test, while analyses of categorical variables were conducted using a Fisher exact test.

Characteristics between admissions that did and did not utilise alpha-blockade were compared initially with univariate analyses.

Next, regression analyses were conducted to determine the impact of alpha-blockade on ICU length of stay, hospital length of stay, billed charges, and inpatient mortality. Logistic regression was utilised for inpatient mortality. Linear regressions were utilised for lengths of stay and billed charges. The dependent variable was one of the aforementioned outcomes, while the dependent variables included congenital cardiac malformations, the comorbidities previously mentioned, and alpha-blockade. All regressions conducted in a stepwise backward fashion using the likelihood ratio. All the variables outlined in Table 1 were used as independent variables. As all the variables of interest including in this study were already selected based on previous data, the variables entered into the stepwise regression were already selected a priori. This initial selection of variables based on theoretical data from previous data was done to help improve the performance of the stepwise regression.

All statistical analyses were conducted using SPSS, Version 23.0. A p-value of less than 0.05 was considered statistically significant. Any use of the word "significant" throughout this manuscript implies statistical significance unless otherwise specified.

Results

Frequency of use of alpha-blockade (Table 1)

A total of 81,313 admissions were included in the final analyses. Of these, 4309 (5.3%) utilised alpha-blockade. Phenoxybenzamine was utilised infrequently and was not recorded as being used in admissions after 2010. Only 19 of the alpha-blockade admissions utilised phenoxybenzamine. Thus, phentolamine accounts for nearly all of the alpha-blockade in these analyses. Phentolamine was utilised in 4290 admissions. Table 1 outlines the proportion of admissions in which alpha-blockade was utilised each year. The frequency of use increased from 2004 to 2010 and then decreased from 2011 to 2015 ($p < 0.01$).

Alpha-blockade, univariate analyses (Table 2)

Admissions with alpha-blockade were significantly more likely to be male and of younger age. Alpha-blockade was significantly more likely in admissions with severe cardiac lesions such as transposition of great vessels odds ratio 1.6, hypoplastic left heart syndrome (odds ratio 1.8), coarctation of the aorta (odds ratio 2.6), interrupted aortic arch (odds ratio 2.8), and total anomalous pulmonary venous connection (odds ratio 1.8). Similarly, alpha-blockade was significantly more likely in admissions with complex

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Table 1. The absolute number and percentage of congenital heart surgery admissions utilising alpha-blockade for each year

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	All years
Phenoxybenzamine	5 (0.1%)	1 (<0.1%)	2 (<0.1%)	9 (0.2%)	0 (0.0%)	2 (<0.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	19 (0.4%)
Phentolamine	203 (4.7%)	313 (7.3%)	549 (12.7%)	458 (10.6%)	325 (7.5%)	404 (9.4%)	466 (10.8%)	377 (8.7%)	123 (2.9%)	444 (10.3%)	411 (9.5%)	217 (5.0%)	4290 (99.6)
Alpha-blockade	208 (4.8%)	314 (5.4%)	551 (12.8%)	467 (10.8%)	325 (7.5%)	406 (5.8)	466 (10.8%)	377 (8.7%)	123 (2.9%)	444 (10.3%)	411 (9.5%)	217 (5.0%)	4309 (100%)

cardiac surgeries, such as total repair of anomalous pulmonary venous connection (odds ratio 1.7), total repair of common arterial trunk (odds ratio 1.8), arterial switch (odds ratio 2.5), right ventricle to pulmonary artery conduit (odds ratio 1.6), and systemic to pulmonary artery shunt (odds ratio 2.1).

Alpha-blockade was significantly more likely in admissions with comorbidities, such as heart failure (odds ratio 2.0), tachyarrhythmia (odds ratio 1.2), and acute kidney injury (odds ratio 2.8). Alpha-blockade was also significantly more likely in admissions requiring dialysis (odds ratio 1) or extracorporeal membrane oxygenation (odds ratio 1.7). Mortality was greater in alpha-blockade admissions (7.9% versus 4.4%, $p < 0.01$).

Alpha-blockade, regression analyses (Table 3)

Alpha-blockade was significantly, independently associated with a 1.5 days reduction in ICU length of stay ($p < 0.01$) and a 3.5 days reduction in total length of stay ($p < 0.01$). Alpha-blockade was significantly, independently associated with a reduction in mortality (odds ratio 0.8, 95% confidence interval 0.7 to 0.9). Alpha-blockade was not independently associated with any significant change in billed charges. The factors statistically significantly associated with the specific dependent variables are listed along with their unstandardised beta-coefficient and p-value for the following outcomes: ICU length of stay, mortality, and billed charges (Supplementary Table 2).

Discussion

These analyses demonstrate that use of alpha-blockade (either phenoxybenzamine or phentolamine) during paediatric cardiac surgery admissions is independently associated with decreased ICU length of stay, total length of stay, and decreased mortality after adjusting for covariates. This is without a concomitant significant increase in billed charges. Previous reports of the use of alpha-blockade in paediatric cardiac surgery admissions have shown favourable effects.[5–10]

The univariate analyses demonstrate a pattern consistent with alpha-blockade being more frequently used in cardiac lesions palliated or repaired in the neonatal period such as double outlet right ventricle repair (Risk-adjustment Congenital Heart Surgery-1 category 3), hypoplastic left heart syndrome (Norwood procedure, Risk-adjustment Congenital Heart Surgery-1 category 6), transposition (arterial switch, Risk-adjustment Congenital Heart Surgery-1 category 4), common arterial trunk (truncus arteriosus repair, Risk-adjustment Congenital Heart Surgery-1 category 4), and total anomalous pulmonary venous connection repair (Risk-adjustment Congenital Heart Surgery-1 category 4). These findings are not particularly surprising as these neonatal palliations and repairs continue to represent the congenital heart surgery interventions with greatest morbidity and mortality according to the Risk-adjustment Congenital Heart Surgery-1 classification.[11] A study by Ithurrlhade et al. Risk-adjustment Congenital Heart Surgery-1 in the neonatal population showed no statistical significance of mortality in between different paediatric age groups (neonates, infants, and children over 1 year). Furthermore, they also proved that Risk-adjustment Congenital Heart Surgery-1 in the neonatal population was a significantly more powerful mortality predictor than in any other paediatric age group.[12]

A report of alpha-blockade after cardiopulmonary bypass can be found quite early in the experience with cardiopulmonary bypass. Sakauchi and colleagues hypothesised that the effect of

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Table 2. The results of univariate analyses comparing congenital heart surgery admissions with and without alpha-blockade

Characteristics	No alpha-blockade (n = 77,004)	Alpha-blockade (n = 4309)	Odds ratio (95% confidence interval)
Cohort characteristics			
Gender (male)	42,924 (55.7)	2524 (58.6)	–
Age (years)	0.1 (0–17)	0.8 (0–17)	–
Cardiac lesion			
Primum atrial septal defect	1560 (2.0)	66 (1.5)	0.7 (0.5–0.9)
Secundum atrial septal defect	39,633 (51.5)	2566 (59.5)	1.3 (1.1–1.4)
Ventricular septal defect	25,583 (33.2)	1528 (35.5)	1.2 (1.1–1.3)
Double outlet right ventricle	8299 (10.8)	516 (12.0)	1.2 (1.1–1.3)
Tetralogy of Fallot	8231 (10.7)	352 (8.2)	0.7 (0.6–0.8)
Pulmonary atresia	4344 (5.6)	117 (2.7)	0.4 (0.3–0.6)
Atrioventricular septal defect	10,135 (13.2)	486 (11.3)	0.8 (0.7–0.9)
Transposition	7553 (9.8)	649 (15.1)	1.6 (1.4–1.7)
Congenitally corrected transposition	1108 (1.4)	59 (1.4)	0.9 (0.7–1.2)
Common arterial trunk	2128 (2.8)	172 (4.0)	1.4 (1.2–1.7)
Ebstein anomaly	1229 (1.6)	40 (0.9)	0.5 (0.4–0.7)
Hypoplastic left heart syndrome	11,757 (15.3)	1076 (25.0)	1.8 (1.7–1.9)
Functionally univentricular heart other than HLHS	5063 (6.6)	218 (5.1)	0.7 (0.6–0.8)
Coarctation of the aorta	5664 (7.4)	760 (17.6)	2.6 (2.4–2.9)
Interrupted aortic arch	1260 (1.6)	198 (4.6)	2.8 (2.4–3.3)
Partial anomalous pulmonary venous connection	2165 (2.8)	85 (2.0)	0.6 (0.5–0.8)
Total anomalous pulmonary venous connection	3486 (4.5)	346 (8.0)	1.8 (1.6–2.0)
Systemic venous anomaly	2860 (3.7)	137 (3.2)	0.8 (0.7–1.0)
Congenital tricuspid stenosis	4.663 (6.1)	153 (3.6)	0.5 (0.4–0.6)
Congenital mitral stenosis	1593 (2.1)	131 (3.0)	1.4 (1.2–1.7)
Congenital pulmonary stenosis	4397 (5.7)	147 (3.4)	0.5 (0.4–0.6)
Congenital aortic stenosis	1432 (1.9)	116 (2.7)	1.4 (1.2–1.7)
Congenital subaortic stenosis	1823 (2.4)	132 (3.1)	1.3 (1.1–1.5)
Congenital pulmonary artery anomaly	4228 (5.5)	131 (3.0)	0.5 (0.4–0.6)
Congenital coronary anomaly	2792 (3.6)	167 (3.9)	1.1 (0.9–1.2)
Cardiac surgery			
Valvuloplasty without replacement, unspecified valve	99 (0.1)	5 (0.1)	0.9 (0.3–2.2)
Valvuloplasty without replacement, aortic valve	1968 (2.6)	102 (2.4)	0.9 (0.7–1.1)
Valvuloplasty without replacement, mitral valve	3356 (4.4)	132 (3.1)	0.7 (0.5–0.8)
Valvuloplasty without replacement, pulmonary valve	2686 (3.5)	101 (2.3)	0.6 (0.5–0.8)
Valvuloplasty without replacement, tricuspid valve	4434 (5.8)	189 (4.4)	0.7 (0.6–0.8)
Replacement, unspecified valve	19 (0.1)	1 (0.1)	0.9 (0.1–7.0)
Tissue replacement, aortic valve	807 (1.0)	47 (1.1)	1.0 (0.7–1.4)
Mechanical replacement, aortic valve	521 (0.7)	14 (0.3)	0.4 (0.2–0.8)
Tissue replacement, mitral valve	129 (0.2)	5 (0.1)	0.6 (0.2–1.6)
Mechanical replacement, mitral valve	745 (1.0)	29 (0.7)	0.6 (0.4–1.0)
Tissue replacement, pulmonary valve	2023 (2.6)	42 (1.0)	0.3 (0.2–0.4)
Mechanical replacement, pulmonary valve	1213 (1.6)	25 (0.6)	0.3 (0.2–0.5)
Tissue replacement, tricuspid valve	122 (0.2)	5 (0.1)	0.7 (0.2–1.7)
Mechanical replacement, tricuspid valve	230 (0.3)	3 (0.1)	0.2 (0.1–0.7)

(*Continued*)

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Table 2. (*Continued*)

Characteristics	No alpha-blockade (n = 77,004)	Alpha-blockade (n = 4309)	Odds ratio (95% confidence interval)
Operation on papillary muscle	168 (0.2)	6 (0.1)	0.6 (0.2–1.4)
Operation on chordae tendineae	121 (0.2)	5 (0.1)	0.7 (0.3–1.8)
Annuloplasty	1111 (1.4)	43 (1.0)	0.6 (0.5–0.9)
Infundibulectomy	1524 (2.0)	70 (1.6)	0.8 (0.6–1.0)
Enlargement of existing atrial septal defect	6641 (8.6)	835 (19.4)	2.5 (2.3–2.7)
Creation of septal defect	4779 (6.2)	377 (8.7)	1.4 (1.2–1.6)
Repair of atrial septal defect	1792 (2.3)	53 (1.2)	0.5 (0.3–0.6)
Repair of ventricular septal defect with prosthesis	7176 (9.3)	370 (8.6)	0.9 (0.8–1.0)
Repair of ventricular septal defect with tissue	7810 (10.1)	561 (13.0)	1.3 (1.2–1.4)
Repair of atrioventricular septal defect with prosthesis	2159 (2.8)	57 (1.3)	0.4 (0.3–0.6)
Repair of atrioventricular septal defect with tissue	5229 (6.8)	245 (5.7)	0.8 (0.7–0.9)
Total repair of tetralogy of Fallot	5670 (7.4)	271 (6.3)	0.8 (0.7–0.9)
Total repair of anomalous pulmonary venous connection	3434 (4.5)	325 (7.5)	1.7 (1.5–1.9)
Total repair of common arterial trunk	1254 (1.6)	130 (3.0)	1.8 (1.5–2.2)
Arterial switch	4760 (6.2)	628 (14.6)	2.5 (2.3–2.8)
Atrial switch	1640 (2.1)	100 (2.3)	1.0 (0.9–1.3)
Right ventricle to pulmonary artery conduit	5866 (7.6)	524 (12.2)	1.6 (1.5–1.8)
Heart transplant	2441 (3.2)	51 (1.2)	0.3 (0.2–0.4)
Systemic to pulmonary artery shunt	11,016 (14.3)	1123 (26.1)	2.1 (1.9–2.2)
Glenn	8859 (11.5)	346 (8.0)	0.6 (0.5–0.7)
Fontan	7203 (9.4)	201 (4.7)	0.4 (0.4–0.6)
Comorbidities			
Syndrome	12,708 (16.5)	623 (14.5)	0.8 (0.7–0.9)
Heart failure	3601 (4.7)	397 (9.2)	2.0 (1.8–2.3)
Tachyarrhythmia	7738 (10.0)	476 (11.0)	1.2 (1.1–1.3)
Bradyarrhythmia	6763 (8.8)	343 (8.0)	0.9 (0.8–1.0)
Acute kidney injury	4969 (6.5)	711 (16.5)	2.8 (2.6–3.1)
Need for dialysis	1735 (2.3)	410 (9.5)	4.5 (4.0–5.1)
Pulmonary hypertension	6801 (8.8)	273 (6.3)	0.7 (0.6–0.8)
Medications			
Steroids	39,282 (51.0)	1960 (45.5)	0.8 (0.7–0.9)
Phentolamine	0 (0.0)	4290 (99.6)	–
Phenoxybenzamine	0 (0.0)	19 (0.4)	–
Complications			
Cardiac arrest	2448 (3.2)	143 (3.3)	1.0 (0.8–1.2)
Need of extracorporeal membrane oxygenation	4256 (5.5)	405 (9.4)	1.7 (1.5–1.9)
Admission characteristics			
ICU length of stay (days)	4 (0–996)	9 (0–199)	–
Total length of Stay (days)	10 (1–997)	18 (1–223)	–
Billed charges (US dollars)	171,458	291,299	–
Inpatient mortality	3388 (4.4%)	340 (7.9%)	1.9 (1.7–2.1)

Abbreviations: HLHS=hypoplastic left heart syndrome; ICU=intensive care unit; N = number of patients; US=United States.

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Table 3. The results of regression analyses to determine the effect of alpha-blockade on admission characteristics

ICU length of stay	Total length of stay	Billed charges (US dollars)	Mortality
−1.5 days ($p < 0.01$)	−3.5 days ($p < 0.01$)	+12,926 ($p = 0.12$)	0.8 (0.7–0.9)*

Abbreviations: ICU=intensive care unit; US=United States.
*Odds ratio (95% confidence interval).

cardiopulmonary bypass may be similar to haemorrhagic shock and thus felt that phenoxybenzamine may be beneficial. They demonstrated increased blood flow to the heart and brain with decreased blood flow to the kidneys and also found that beta-glucuronidase activity increased after cardiopulmonary bypass. Administration of phenoxybenzamine reversed these findings and was found to be helpful in promoting systemic blood follow and oxygen delivery.[13]

Since this early report, much has been learned about the utility of peri-operative and post-operative alpha-blockade. Peri-operative use of alpha-blockade allows for higher cardiopulmonary bypass pump flows which has been associated with decreased peri-operative metabolic acidosis.[8,9,14] As previously shown, alpha-blockade may have a pulmonary vasodilating effect that can be of benefit in certain patient populations[6,7,15–18]. Alpha-blockade has also been demonstrated to improve coronary flow.[19]

There are some possible side effects associated with the use of alpha-blockade, the most common being hypotension. Phenoxybenzamine-induced hypotension can be ameliorated by fluid administration and vasopressin.[20] Phentolamine-induced hypotension can be ameliorated by altering the dose of or discontinuing phentolamine. Fluid administration can also help ameliorate phentolamine-induced hypotension.

Use of and availability of phenoxybenzamine has decreased significantly over the years as the price of the agent has become prohibitive at many centres. The current analyses cover an era in which the use of phenoxybenzamine was nearly absent. The early study period did find some recorded use of phenoxybenzamine although even this was minimal. Phentolamine represents the major agent used for alpha-blockade in the current era.

These analyses represent, to our knowledge, the largest series of congenital heart surgery patients for whom data regarding alpha-blockade have been reported. The data identify patterns in the use of alpha-blockade and also demonstrate independent associations with admission characteristics.

These analyses, however, are not without their limitations. Firstly, the data come from a retrospective administrative database and so incorrect coding, variable coding practices, and non-coding may impact the frequencies and associations (although to a lesser extent) in these analyses. Furthermore, the ability to categorise diagnoses and/or surgeries with this data source is limited. It must also be kept in mind that the patient populations identified in the univariate analyses do not represent patient populations in whom alpha-blockade is more beneficial but simply describes the bias of providers as to what patient populations receive alpha-blockade. Subset analyses could not be reliably conducted to identify specific patient populations that may benefit more than others from alpha-blockade. Additionally, the timing of alpha-blockade cannot be discerned. And thus, whether timing of alpha-blockade impacts the effect cannot be commented upon.

An additional limitation is also the general shortcomings of regression analyses. There is no one ideal approach to regression analyses. We chose to use a stepwise approach since our variables of interest (which included cardiac diagnoses, cardiac surgeries, and comorbidities) were already selected to be variables of particular interest. The a priori selection of variables in the setting of stepwise regressions does seem to help improve model stability and performance. We elected to use a stepwise regression method versus a penalised regression method as stepwise regressions are not always outperformed by penalised regression methods as commonly believed. A study by Morozova colleagues, in fact, demonstrated greater model stability with stepwise regression utilising backward elimination with likelihood ratio testing than when compared to using penalised regression models [21].

It should be noted that ICU length of stay, total length of stay, inpatient mortality, and billed charges were all significantly higher in the alpha-blockade admissions by univariate analyses. Regression analyses demonstrated that other factors were actually behind these increases and that alpha-blockade was actually independently associated with decreased ICU stay, total length of stay, and mortality. There was no independent association with any significant change in billed charges.

Conclusion

Alpha-blockade is used in a small proportion of congenital heart surgery admissions. Its use is mostly in neonatal cardiac palliations or repairs, specifically hypoplastic left heart syndrome, transposition, and common arterial trunk. Alpha-blockade was independently associated with decrease in ICU length of stay, hospital length of stay, and mortality without increasing billed charges.

Supplementary material. To view supplementary material for this article, please visit https://doi.org/10.1017/S1047951121003875

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