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Coarctation of the aorta: to extubate early or to extubate late

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Keypoints

In our study which we tried to find out whether it is better to implement on table extubation as part of a fast track protocol for managing patients following surgical repair of coarctation of the aorta; or it is better to leave patients intubated for later delayed management in the ICU. We found the extubation didn't add much to the ease of handling such patients in the ICU in addition it was associated with the need for a higher doses of vasodilators and analgesics.

Abstract

Introduction

Coarctation of the aorta is a common congenital abnormality that requires surgical repair in most instances with a challenging anesthetic management. Fast tracking has been introduced to cardiac anesthesia in order to limit post - operative ventilator complications, to conserve expensive resources and to allow a shorter hospital course. Immediate extubation is an integral part of fast tracking which is a composite term involving multidisciplinary management.

Aim and objective

We compared the post - operative course of 2 groups of children who had surgical repair of coarctation of the aorta through lateral thoracotomy; one group was immediately extubated in the OR; on table extubation (OTE) at the end of surgery and the other was left intubated and transferred ventilated to the ICU. We compared the adequacy of BP control (estimated from the average hourly rate of nitroglycerin infusion), the need for reintubation, the incidence of occurrence of surgical bleeding and the post - operative ICU stay.

Material and methods

A total of 60 patients (2 months - 6 years) were randomly assigned into one of the two groups: one group (group E) were extubated at the end of the procedure and the other group (group I) were left intubated and transferred ventilated to the ICU. The patients in both groups were closely monitored for BP rise postoperatively (as related to the 50th percentile of the BP tables obtained from "The Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents, NIH, 2005), the rate of nitroglycerin infusion as a vasodilator was also recorded, the need for reintubation was reported in both groups together with the occurrence of bleeding that necessitates surgical control and also the length of ICU stay was reported.

Results

Immediate extubation; on table extubation (OTE) of children who have had surgical repair for coarctation of

the aorta was associated with a higher post - operative blood pressure that required higher hourly doses of vasodilators. Also it was noticed that trying to control BP using supplemental opioid analgesia partly caused respiratory depression that required reintubation. The rise of BP that followed immediate extubation might be the cause for post - operative bleeding that required surgical exploration. In addition, immediate extubation didn't result in a significantly reduced post-operative ICU stay.

Conclusion

The practice of immediate extubation; on table extubation (OTE) in the OR for children who underwent surgical repair of aortic coarctation via thoracotomy did not decrease post - operative ICU stay and it was associated with the need for a higher doses of vasodilators and increased incidence of bleeding and reintubation.

Keywords: Aorta, coarctation, surgical repair, extubation

Introduction

Coarctation of Aorta (CoA) is a congenital abnormality of the heart producing obstruction to blood flow through the aorta; it consists of a constricted aortic segment comprising localized medial thickening with some infolding of the media and superimposed neointimal tissue. It may be a shelf - like structure or a membranous curtain - like structure with an eccentric or a central opening. Most commonly it is located at the junction of the ductus arteriosus with the aortic arch, just distal to the left subclavian artery. Rarely, the coarcted segment is present in the lower thoracic or abdominal aorta, long and fusiform with irregular lumen and may be considered as a variant of Takayasu arteritis. Coarctation can occur in isolation, in association with bicuspid aortic valve or with major cardiac malformations [(1)]. CoA accounts for 5 - 8% of children born with congenital heart disease [(2,3)]. The majority of coarctations are newly diagnosed in childhood; less than 25% are recognized beyond 10 years of age [(4)]. Despite the extensive experience and knowledge regarding CoA, there are controversies when it comes to its management in children. Surgical correction was first performed in mid 1940s [(5,6)] and since then it has become standard method of therapy for CoA. Transcatheter balloon angioplasty of CoA began in late 1970s but became more popular in late 1980s thru' early 1990s [(7)]. Over the past decade we have started using intravascular stents for management of coarctation, mainly in adolescents and adults [(8)].

Management

The majority of patients affected present in infancy with hypertension associated with varying degrees of heart failure which reflect predominantly the severity of the aortic narrowing.

Ultimately, these patients require intervention; surgery is the treatment of choice in this age group, although balloon angioplasty has been used as a bridge to surgery in critically ill infants [(9)].

Early recognition is paramount, because rapid deterioration may occur with closure of the arterial duct and there is a trend towards less favorable outcomes in sicker preoperative infants [(10)].

In either case, intensive management is required to ensure ventricular function is optimal prior to surgery.

Various surgical approaches have been used, with the two commonest recent approaches being surgical excision of the coarctation with end-to-end anastomosis or augmentation of the coarcted aorta using the subclavian artery, the so-called 'subclavian flap repair' (SFR). Although reports are conflicting on the longer term outcomes of these two surgical approaches, most have concentrated on survival, the need for re-intervention and aneurysm formation [(11,12)].

Catheter intervention

Non - surgical approaches to CoA became popular with the advent of balloon angioplasty. Balloon angioplasty for coarctation was first reported in 1982, and became widespread over the past two decades [(13)]. Medium term outcome studies of balloon angioplasty have shown good initial relief of stenosis, but high rates of recoarctation and aneurysm formation [(14-17)].

Hence, stent implantation is now the preferred intervention for coarctation in older children and adults, with persistent relief of stenosis and lower incidence of aneurysm formation compared to balloon angioplasty alone [18,19]. Fast - tracking in cardiac surgery refers to the concept of early extubation, mobilization and hospital discharge in an effort to reduce the cost and perioperative morbidity [20,21]. Economic concerns such as significant increases in overall medical expenses and the accumulating data that patient's care is not jeopardized have made the concept of fast - tracking attractive for practitioners involved in the care of children with congenital heart disease (CHD) [22]. Potential advantages of fast - tracking following surgery for CHD are: Reduced ventilator associated complications, reduced requirements of sedatives (and associated hemodynamic compromise), more rapid patient mobilization, earlier intensive care unit (ICU) discharges, decreased length of hospital stay and reduced patient or parental stress. Patient and parent satisfaction is increased in children who are extubated in the operating room (OR) or soon after ICU arrival. Early extubation allows earlier mobilization and verbal communication between the child, parents and hospital staff involved. Prolonged mechanical ventilation in children can be one of the most distressing experiences for the patient and parents [23]. On - table extubation (OTE); extubation of the patient in the operating room immediately (usually within 15 minutes) after surgery, is not uncommonly practiced in adult surgery, especially off - pump coronary artery surgery as a component of fast - track protocol though not frequently done in pediatric cardiac surgery. The benefits of the fast - track pathways must be always weighed against safety and the achievement of excellent outcome. OTE, as compared to early extubation (within 4 hours of surgery) is much less practiced in pediatric cardiothoracic surgeries [24].

Materials and methods

The study was conducted from May 2013 to February 2014 in the cardiothoracic unit of the specialized pediatric hospital of the faculty of medicine in Cairo University. After obtaining approval of the ethical committee and taking a written informed consent from the patients' guardians, 60 patients having coarctation of the aorta, aged 2 months to 6 years were enrolled in the study. They were randomly assigned using computer generated randomization into 2 groups (E group) where extubation was done in the OR and (I group) where the patients were transferred intubated to the ICU.

Exclusions included patients with associated other cardiac anomalies (e.g. VSD), patients with airway abnormality, patients with heart failure, patients with endocrine disorders, patients with coagulopathies and patients presenting for redo surgery.

The patients were sedated using IM midazolam (0.2 mg/kg) with atropine (0.02 mg/kg) prior to anesthesia, then they were transferred to the OR where the patients were placed on a warming mattress, all non - invasive monitors were applied (ECG, pulse oximetry and non - invasive BP), anesthesia was induced using sevoflurane inhalation at 4% in a mixture of o_2 and air (Fio_2 0.5), then an IV line was inserted, analgesia was obtained using fentanyl at 4 µcg/kg, muscle relaxation was achieved using atracurium (0.5 mg/kg as induction followed by 0.1 mg/kg every 25 minutes as maintenance).

A left sided IJV CVL was inserted. A right upper limb arterial line was put (radial and less frequently brachial). Invasive arterial BP values were taken as a baseline for later correlation and a nasopharyngeal temperature probe was inserted. A urinary catheter was inserted and then the patients were placed in the left lateral position, an axillary roll was placed under the right axilla.

A left thoracotomy was performed. Dissection commenced reaching the narrowed segment of the aorta. Heparin was given prior to clamping (100 IU/kg) and then clamps were applied. Vasodilator therapy was instituted using nitroglycerin. Repair was done using either end to end, extended end to end or subclavian flap techniques. After completion of the repair, clamps were removed, protamine sulphate was given at 1 mg/kg for each 100

IU/kg heparin to reverse the heparin action and hemostasis was done. Closure was done in layers after expanding the collapsed lung and a supplemental intercostal nerve blockade was done to provide analgesia. The final rate of nitroglycerin infusion was recorded for later correlation with the nitroglycerin infusion dosage in the ICU. Post - operative pain was managed using pethedine 0.5 - 1 mg/kg IV and Paracetamol 7.5 mg/kg IV infusion. The patients were monitored for the first 12 hours following surgery for BP, nitroglycerin infusion rate was averaged over the first 12 hours (recording the infusion rates every 4 hours and taking the average for reference), need for reintubation and the occurrence of surgical bleeding that required operative exploration.

Statistical analysis

Sizing of the study samples was based on data obtained from previous studies on fast tracking in pediatric cardiac surgery. Calculation of the sample size revealed that at least 24 patients in each group were needed. The sample size was increased by 25% (i.e. 30 patients in each group) to compensate for dropouts. Statistical analysis was performed using statistical package for social science version 21.0, (IBM Corporation, Armonk, New York, USA) distributed continuous data were represented as mean and SD; one-way analysis of variance was used to test the difference between values within the study groups and paired Student's t-test was used to compare different group data. A *P* value less than 0.05 was considered significant.

Results

Of the 60 patients that were enrolled in the study, 34 (56.7 %) were males, 26 (43.3 %) were females (figure 1). The age of the patients ranged from 2 months to 6 years. Of the 60 patients, 42 (70 %) had an end to end repair and 18 (30 %) had subclavian flap repair. Aortic clamping time ranged from 11 to 18 minutes. There were no statistically significant differences as regard the age and weight of the patients between the 2 groups (table 1).

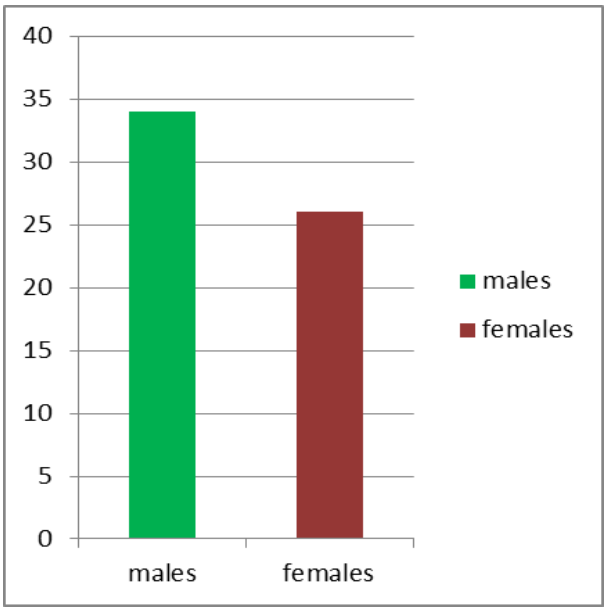

Figure 1. Male and female distribution among study patients

	I group	E group
Age	1.587±1.452	1.54±1.519
Weight	6.625±3.484	6.575±3.742

Table 1. Age and weight values of both study groups

Patients within the early extubation group (E group) required a higher nitroglycerin infusion dosage (4.267±1.365 µcg/kg/min) to keep their blood pressure within the range of the blood pressure for the age as compared to the group that was left intubated (I group)at the end of surgery (3.533±1.147 µcg/kg/min) (figure 2). The P-Value is 0.015339. The result is significant at $p < 0.05$. There was no statistically significant difference as regard the post-operative ICU stay, (3.467±0.991 days) in the (E group) as compared to 3.633±0.948 days) in the (I group) (figure 3). The P-Value is 0.257722. The result is *not* significant at $p < 0.05$.

Two patients (6.667 %) had surgical bleeding that required exploration in the (E group) as compared to 1 patient (3.333 %) in the (I group). As regard the need for reintubation, 3 patients were reintubated in the (E group); namely those who needed surgical exploration for bleeding and one following respiratory depression 2ry to opioid overdose, while only 2 required reintubation wi-

thin the (I group); the one who was surgically explored and another one who had acute pulmonary edema.

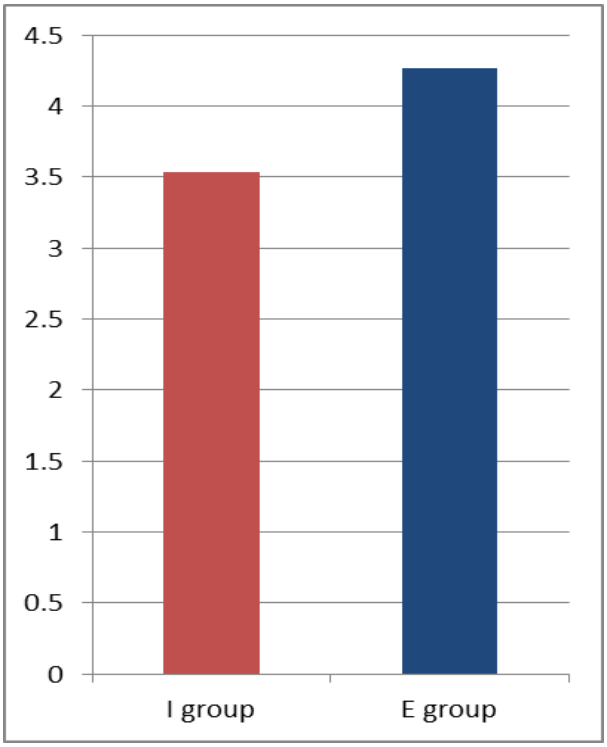

Figure 2. Average nitroglycerin infusion rate within the I group and the E group

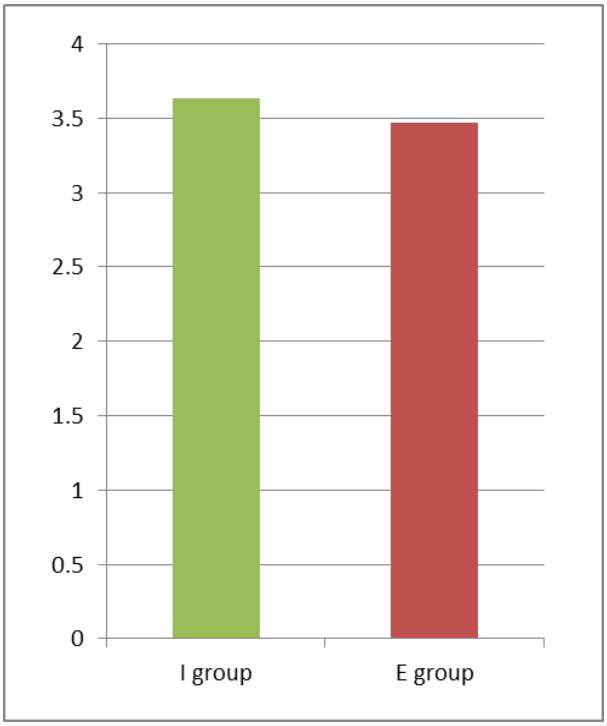

Figure 3. Average ICU stay in group (I) and group (E)

Discussion

Coarctation of Aorta (CoA) is a congenital abnormality of the heart producing obstruction to blood flow through the aorta; it consists of a constricted aortic segment comprising localized medial thickening with some infolding of the media and superimposed neointimal tissue. Significant hypertension and congestive heart failure are indications for intervention. Options include surgery through lateral thoracotomy or balloon angioplasty [25]. Surgeries for repair of aortic coarctation are usually short timed surgeries and do not involve complex surgical maneuvers and this was in part a good reason to give the anesthetists the chance to try practicing fast tracking. The post - operative course of patients following repair of coarctation is often concerned about controlling residual hypertension, maintaining adequate end organ perfusion and prevention of iatrogenic complications in the ICU.

The increased need for efficient use of limited healthcare resources resulted in the adoption of early tracheal extubation techniques in cardiac surgery [21,26]. Early extubation has been documented in adults [27] and children [28,29] to avoid the potentially deleterious effects of mechanical ventilation such as laryngotracheal trauma, barotrauma, pneumothorax, mucus plugging, incorrect positioning or kinking of endotracheal tube, accidental extubation [30].

In addition, the postoperative use of sedative and analgesic drugs, to facilitate tolerance of the endotracheal tube, may prolong the duration of intubation [30].

Ventilation of postoperative patients undergoing cardiac operations has been a standard practice for the past three decades [31]. This practice has been a driving force for fast-track cardiac anesthesia [27,32]. It was realized that patients who got early extubation, had shorter ICU and hospital stay and therefore lower cost of care [33]. The opponents to early extubation argue that the immediate perioperative period is the most critical for hemodynamic instability and sympathetic nervous system activation [34].

The concern about immediate extubation is the potential for reintubation and ventilation for respiratory failure in the immediate postoperative period.

In our study we tried to address how far on table extubation would be beneficial as compared to the traditional practice of transferring patients intubated to the ICU following surgical repair of aortic coarctation.

In our study, we found that patients within the group where immediate extubation was done required a higher dosage of nitroglycerin infusion within the first 12 hours to control residual hypertension as compared to those that were left intubated for ICU transfer. This may be partly explained by a higher sympathetic tone in a fully awake extubated child and partly due to fear of using a high dosage of opioids to control pain for fear of respiratory depression that may lead to reintubation.

There was no difference as regard the duration of ICU stay at the studied age group. Zureikat et al studied the practice of early extubation following congenital cardiac surgery in slightly older patients (age 6 months - 14 years) and found that early extubation was associated with a shorter ICU stay [(35)].

This could be explained by considering younger and smaller children to have less cardio - respiratory reserves and they need longer time to restore their normal status following anesthesia and surgery.

Two patients (6.667 %) had surgical bleeding that required exploration in the group that was extubated immediately as compared to 1 patient (3.333 %) in the group that was left intubated.

Control of post - operative hypertension is always a surgical requirement for fear of suture disruption. Bleeding might be related to the rise of BP that may occur post - operatively.

When it came to addressing the need for reintubation, 3 patients were reintubated in the (E group); namely those who needed surgical exploration for bleeding and one following respiratory depression 2ry to opioid overdose, while only 2 required reintubation within the (I group); the one who were surgically explored and another one who had acute pulmonary odema.

Akhtar et al validated the safety of fast track extubation (within 6 hours of surgery) in pediatric congenital heart surgeries but they included older patients and a wider age range [(36)].

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