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Anesthetic implications and role of preoperative beta blockade in esophageal substitution with stomach in pediatric surgical patients

Raksha Kundal¹, Ranju Singh^{1*} , Subhasis Roy Choudhury², Partap Singh Yadav², Ajai Kumar¹, Shalu Gupta³ and Vijay Kumar Kundal⁴

Abstract

Background: There is a paucity of literature on the anesthetic management of pediatric esophageal substitution using the stomach. We did a retrospective analysis of all such cases done at our institution. We analyzed the patient's demography, indication, and type of surgery, co-morbid conditions, anesthesia techniques, duration of postoperative ventilation, hospital stay, complications, and mortality. The use of beta-blockers and their effect on the incidence of intraoperative and postoperative tachycardia in gastric pull-up patients was also analyzed.

Results: Thirty-four cases of gastric substitution of the esophagus in children were done over 19-year period; gastric pull-up was done in 28 patients and a gastric tube was made in 6 patients. General anesthesia was given to all; a thoracic epidural for pain was sited in 25 patients. Twenty-eight patients were ventilated postoperatively; the mean duration of ventilation is 54 h. Significant intraoperative tachycardia was observed in 85.7% of patients without beta-blocker as compared to 23.8% patients with beta-blocker ($p = 0.004$). Postoperatively, tachycardia was absent in patients receiving beta-blocker and present in 71.4% of patients not receiving beta-blockers ($p < 0.001$). Overall mortality was 8.8% but mortality due to cardiac arrhythmia was 42.9% in the patients not receiving beta-blockers ($p = 0.001$).

Conclusions: A thorough preoperative preparation, control of tachyarrhythmias, postoperative ventilation, and pain management is recommended for a favorable outcome. In addition, our paper supports the preoperative use of beta-blockers in reducing the incidence of fatal tachyarrhythmias associated with gastric pull-up surgery without any serious adverse effects.

Level of evidence: Level III

Keywords: Pediatric, Tracheoesophageal fistula, Tachycardia, Cardiac arrhythmias, Metoprolol

Background

Esophageal substitutions in children are carried out when the functional esophagus is not available in conditions such as long gap esophageal atresia and intractable corrosive stricture (Arul & Parikh, 2008). The stomach

is commonly used as a substitute in the form of either a gastric pull-up (GPU) or a gastric tube (GT). Pediatric esophageal substitution in general and GPU, in particular, have serious anesthetic implications, as it involves significant mediastinal dissection, major fluid shifts, the possibility of intraoperative and postoperative cardiac arrhythmias, hemodynamic instability, considerable postoperative pain, and complications (Spitz, 1984; Jain

* Correspondence: lhmkalawati@rediffmail.com

¹Department of Anesthesia, Lady Hardinge Medical College, New Delhi, India
Full list of author information is available at the end of the article

et al., 2017; Roy Choudhury et al., 2005). The cardiac and respiratory complications are of particular concern as they can lead to patient demise (Spitz et al., 2004).

Since there is a paucity of published literature about the anesthetic management of children undergoing esophageal substitutions with stomach, we undertook this retrospective analysis to highlight the various anesthetic concerns and share our experience of the changing anesthetic management over the years which has led to an improvement in outcome. We hope this will be very helpful to other clinicians who are involved in the care of these challenging cases.

Methods

After approval from the Institutional Ethics Committee for Human Research (LHMC/ECHR/2019/05), data were retrospectively collected and entered into a structured proforma. All pediatric patients who underwent gastric substitution of the esophagus in our tertiary care children's hospital from January 2001 to January 2020 were included in this study. The patient's demography, indication of surgery, co-morbid conditions, anesthesia techniques, postoperative pain control, duration of postoperative ventilation, and pediatric intensive care unit (PICU) stay, complications, duration of stay in the hospital, and mortality were analyzed. The use of beta-blockers and their effect on the incidence of intraoperative and postoperative arrhythmias in gastric pull-up patients was also analyzed.

Statistical analysis was done with the statistical package for the Social Science System (SPSS) version 20.0. Categorical variables were expressed as frequencies and percentages. The comparison of continuous variables between the groups was performed using Student's *t* test. Nominal categorical data between the groups were compared using Chi-squared test or Fisher's exact test as appropriate. Non-normal distribution continuous variables were compared using the Mann-Whitney *U* test. For all statistical tests, a *p* value less than 0.05 was taken to indicate a significant difference.

Results

A total of 34 patients were operated on from January 2001 till January 2020. Demographic data and anesthesia techniques are shown in Table 1. The indication for surgery and surgical procedures along with their relation to mortality is depicted in Table 2. The commonest indication was esophageal atresia—Gross Type A anomaly and the commonest surgery was GPU. No co-morbidity was seen except a small ventricular septal defect (2.4 mm) in one patient; an esophageal replacement was done with GT in this patient.

Seven patients operated on before 2005 did not receive preoperative beta-blockers; the surgical procedure

Table 1 Demography and anesthesia techniques

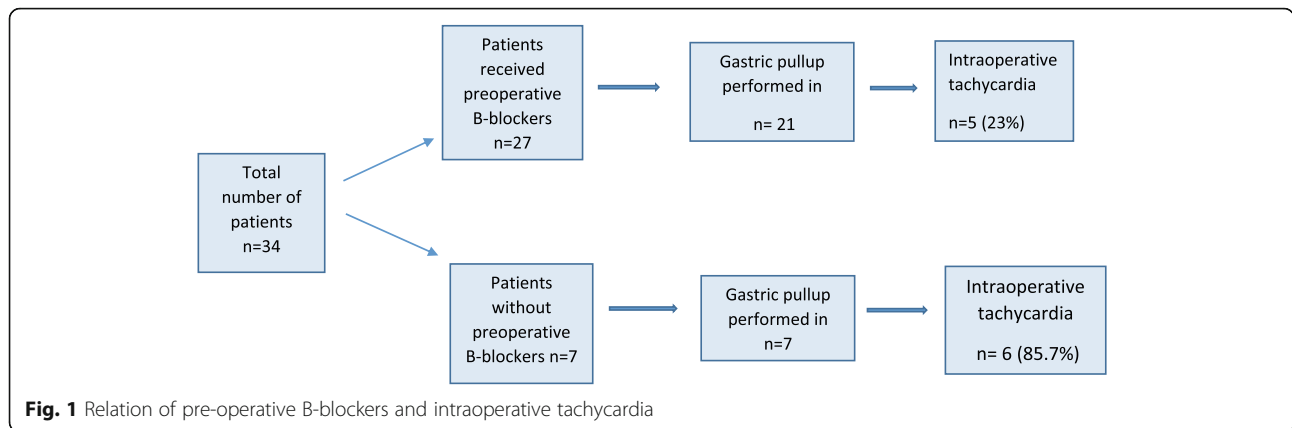
Age (mean \pm SD)	18.39 (\pm 11.24) months
Gender, M/F	23/11
Weight (mean \pm SD)	9.361 (\pm 1.71) kg
Anesthesia techniques: General anesthesia/general anesthesia + epidural block	9/25

performed in all of them was GPU. However, the 27 patients who were operated on after 2005 received preoperative beta-blockers (metoprolol 1 mg/kg 2-3 days before surgery through feeding jejunostomy) in consultation with a pediatrician; GPU was performed in 21 of them (Fig. 1). We compared the incidence of intraoperative and postoperative tachycardia and hypertension in these GPU patients who received or did not receive preoperative beta-blockers. Intraoperative tachycardia was present in 23.8% of patients who received and in 85.7% of patients who did not receive beta-blockers; the difference is statistically significant ($p = 0.004$, Table 3). Intraoperative short-acting beta-blockers were used in 3 of these patients. Tachycardia in the postoperative period was seen in 5 (71.4%) patients of the non-beta-blocker group as compared to zero patients in the beta-blocker group ($p < 0.001$, Table 4).

Postoperatively transient hypertension along with tachycardia developed in two patients of the non-beta-blocker group after GPU, necessitating intravenous infusion of labetalol (0.5-1 mg/kg/h) followed by enteral administration, which was tapered over the next 2 weeks, whereas none of the patients in the beta-blocker group had hypertension in the postoperative period ($p = 0.0015$, Table 4). The incidence of intraoperative and postoperative bradycardia was not significant in these two groups (Tables 3 and 4). One patient in the beta-

Table 2 Indication for surgery, types of surgical procedures, and their relation to mortality

Indications for surgery	Number of patients (%)	
Esophageal atresia (pure) gross type A	27 (79.4)	
Esophageal atresia with tracheoesophageal fistula	4 (11.7)	
Intractable corrosive stricture	3 (8.8)	
Total	34 (100)	
Type of surgery	Number of patients (%)	Mortality (%)
Gastric pull-up	28 (82.3)	3
Gastric tube	6 (17.6)	0
Total	34 (100)	3 (8.82)



blocker group had intraoperative bronchospasm but the incidence was not statistically significant. All patients with GPU ($n = 28$) were electively ventilated in PICU; the mean duration of ventilation is 54 h (range 36 h to 8 days), and the average PICU stay was 4 days (range 2 to 8 days). None of the GT patients ($n = 6$) required postoperative ventilation and were managed in the pediatric surgical ward. Two pneumothoraxes were detected in the postoperative chest X-rays and were managed by the insertion of an intercostal drainage tube. One GPU patient had an acute gastric dilatation managed effectively with decompression through the nasogastric tube. The average hospital stay was 11 days. Three patients of GPU among those 5 who developed tachycardia in the postoperative period developed fatal arrhythmias and died despite all recommended treatments. The overall mortality was 8.8% but mortality due to cardiac arrhythmia was 42.9% in GPU patients who did not receive beta-blockers ($p = 0.001$, Tables 1 and 5).

Discussion

With good surgical expertise and anesthetic management, an excellent long-term outcome can be expected following gastric transposition for esophageal substitution in children (Spitz et al., 2004). The successful management of esophageal substitution surgeries starts from a proper preoperative workup including investigations such as hemoglobin, coagulation status, arterial blood gases, electrolytes, and an echocardiogram to rule out congenital cardiac diseases (Diaz et al., 2005). Indirect laryngoscopy should be done to document the vocal cord status as there are chances of recurrent laryngeal nerve damage during cervical dissection (Cowles & Coran, 2010).

Preoperative fasting should be limited to ensure minimal changes in total body water (Hideki et al., 2012; Søreide et al., 2005). These surgeries are generally associated with major fluid shifts. The bowel is mechanically prepared which results in fluid loss from the

Table 3 Relation of use of beta-blocker with intraoperative tachycardia, bradycardia, and hypertension in GPU patients

Beta-blocker	Intraoperative tachycardia		p value
	Present	Absent	
Administered (n = 21)	5 (23.8%)	16 (76.2%)	p = 0.004
Not administered (n = 7)	6 (85.7%)	1 (14.3%)	
	Intraoperative bradycardia		
	Present	Absent	
Administered (n = 21)	4 (19%)	17 (81%)	p = 0.212
Not administered (n = 7)	0 (0%)	7 (100%)	
	Intraoperative hypertension		
	Present	Absent	
Administered (n = 21)	0 (0%)	21 (100%)	p = 0.011
Not administered (n = 7)	2 (28.6%)	5 (71.4%)	

Table 4 Relation of use of beta-blocker with postoperative tachycardia, bradycardia, and hypertension in GPU patients

Beta-blocker	Postoperative tachycardia		p value
	Present	Absent	
Administered (n = 21)	0 (0%)	21 (100%)	p < 0.001
Not administered (n = 7)	5 (71.4%)	2 (28.6%)	
	Postoperative bradycardia		
	Present	Absent	
Administered (n = 21)	4 (19%)	17 (81%)	p = 0.212
Not administered (n = 7)	0 (0%)	7 (100%)	
	Postoperative hypertension		
	Present	Absent	
Administered (n = 21)	0 (0%)	21 (100%)	p = 0.0015
Not administered (n = 7)	2 (28.6%)	5 (71.4%)	

Table 5 Relation of use of beta-blocker and mortality in gastric pull-up patients

Beta-blockers	Mortality	<i>p</i> value
Administered (<i>n</i> = 21)	0 (0%)	<i>p</i> = 0.001
Not administered (<i>n</i> = 7)	3 (42.9%)	

gastrointestinal tract and reduced preoperative blood volume. Also, prolonged operative time with an open abdominal cavity leads to increased bowel edema and sequestration of fluid. Additionally, hemorrhage during surgery can aggravate the already decreased intravascular volume. Less fluid replacement will lead to hypovolemia and its sequelae and excessive fluids will increase extracellular fluid in lung tissue, impair gas exchange, and may result in postoperative respiratory failure. It will also cause gastrointestinal edema, ileus, and delayed healing of anastomosis; hence, the fluid should be given judiciously. Kita et al. (Kita et al., 2002) have emphasized that positive perioperative fluid balance has poor surgical outcomes in transthoracic esophagectomy while Vermeulen et al. (Vermeulen et al., 2009) have stated that restricted postoperative fluid management in patients of major abdominal surgeries is harmful, accompanied by an increased risk of postoperative complications and prolonged hospital stay. Goal-directed fluid therapy is thus advised and blood transfusion should be given once maximal allowable blood loss is exceeded.

During transhiatal GPU surgery, there is blunt and blind dissection in the posterior mediastinum to create a tunnel for gastric conduit and this mediastinal manipulation causes compression and anterior displacement of the heart, interfering with cardiac filling, resulting in hypotension and arrhythmias which were frequently observed in our patients (Malhotra et al., 2006; Giampiero & Dakshesh, 2016). The severity of hemodynamic disturbances is directly proportional to the duration of mediastinal manipulation; thus, close cooperation between the surgeon and anesthesiologist is a must to minimize the severity of these disturbances (Orringer, 2008). As the hemodynamic disturbances can be acute and severe, it is advisable to have invasive blood pressure monitoring.

Both bradyarrhythmia, as well as tachyarrhythmias, can result during these procedures. Bradycardia is transient, usually resulting from vagal stimulation during manipulation and it can be terminated by withdrawing stimulation. However, if it is persistent, treatment with injection atropine 0.02 mg/kg may be required (Shaffner, 2011). There are many causes of tachyarrhythmia's including pain, pyrexia, hypoxia, hypercarbia, dehydration, and electrolyte imbalance. Vagotomy at higher levels during blunt dissection of posterior mediastinum resulting in damage to branches of cardiac vagal fibers can

also result in tachycardia due to un-counteracted sympathetic stimulation (Yamakawa et al., 2015). Inappropriate sinus tachycardia (IST) progressing to fatal cardiac arrhythmia following GPU in children has earlier been reported (Choudhury et al., 2016). Significant cardiac arrhythmia and hypotension following mediastinal manipulation during transhiatal esophagectomy have also been reported (Amar, 2008). Enhanced sympathetic activity is evidenced by associated increased perspiration under anesthesia; this was observed in our patients having tachycardia (Krahn et al., 1995; Morillo et al., 1994). The uncontrollable tachyarrhythmias with compromised hemodynamic status and resultant mortality caused us to change our practice. We started preoperative tablet metoprolol 1 mg/kg twice a day, starting 2-3 days before surgery to decrease the resting heart rate by 20%. The use of preoperative beta-blockers was associated with a significant decrease in the incidences of arrhythmias and reduction in mortality (*p* = 0.001) which merits special mention. Amer D (Amar, 2008) has also recommended prophylactic therapy for the prevention of perioperative arrhythmias in patients undergoing thoracic surgery. The longer the arrhythmias persist, the more difficult they become to treat, requiring an aggressive approach. Some authors have reported that beta-blockers are not useful in the prevention of postoperative arrhythmias and can cause bradycardia and hypotension (Dunning et al., 2006; Bayliff et al., 1999). We however did not experience any such event.

Transhiatal GPU has an obvious advantage on respiratory function by avoiding thoracotomy and its consequences. However, postoperative elective ventilation becomes necessary as there is large organ sharing space with other structures in the mediastinum resulting in compression of lungs and heart. Additionally, there are chances of airway edema resulting from cervical dissection, development of pneumothorax, pleural effusion, or atelectasis. Elective ventilation with sedation and analgesia is recommended till vitals are stabilized and airway edema settles, as we did in our patients. Sharma S et al. (Sharma & Gupta, 2011) have stated that all of their patients received postoperative elective ventilation for 2-7 days.

Postoperatively, chest X-ray was mandatory to rule out pneumothorax and to check the position of the endotracheal tube and nasogastric tube. A nasogastric tube should be well-secured and cause effective decompression to prevent acute gastric dilation and risk of aspiration. Postoperative hypotension should be avoided as it delays the healing of anastomosis. Since fluid overloading is also detrimental, vasopressor support should be added early. Postoperative analgesia is extremely important and thoracic epidural is known to be associated with decreased risk of anastomotic leakage, improved microcirculation of gastric tube, and improved microcirculation of anastomotic

area (Lazar et al., 2003). We also placed a thoracic epidural catheter, with ropivacaine 0.2% infusions, and, in addition, administered intravenous (IV) opioids and IV paracetamol as a part of multimodal analgesia, as has been recommended by others (Jin & Chung, 2001). Commencing early enteral feeding through the jejunostomy played a crucial role in early postoperative recovery.

Significant morbidity and mortality are reported following GPU surgery in adults but the literature in children is limited (Ujiki et al., 1987). In a large series of gastric transposition in children, Spitz et al. reported 4.6% mortality due to respiratory and cardiac causes although the long-term results were favorable with “normal” quality of life (Spitz et al., 2004). Cowles et al. (Diaz et al., 2005) reported excellent outcomes after gastric transposition surgery in children without detailing the perioperative management. Our overall mortality is 9% but we have had no mortality in the last 21 GPU patients (operated since the year 2005). The improved survival of our patients could be attributed to several factors including better anesthesia practices such as limiting preoperative fasting, judicious fluid use, placement of thoracic epidural, improved PICU care including postoperative ventilation, but the association of beta-blocker use with reduced mortality is remarkably significant and cannot be undermined. Although no comparison was done between the GPU and GT group (due to a small number of cases), our observations suggest that GT was associated with fewer tachyarrhythmias and less need for postoperative ventilation.

Conclusions

We identified certain key areas which require special attention for a successful outcome of gastric substitution of the esophagus in children. A thorough preoperative preparation, control of tachyarrhythmias, pain management, and postoperative ventilation plays a crucial role in achieving a favorable outcome. In addition, our study supports the preoperative use of beta-blockers in reducing the incidence of fatal tachyarrhythmias associated with GPU surgery without any serious adverse effects. This can have enormous clinical implications and can be further investigated in a larger number of patients.

Abbreviations

GPU: Gastric pull-up; GT: Gastric tube; PICU: Pediatric intensive care unit

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Nil

Authors' contributions

RK, RS, SR, and PY contributed to the collection of data and preparation of the manuscript. AK, SG, and VK contributed to manuscript preparation and editing. All authors have read and approved the manuscript.

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Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available due to institutional policy but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Study approved by Lady Hardinge Medical College/Institutional Ethics Committee for Human Research, New Delhi, India (Number-(LHMC/ECHR/2019/05)).

Informed consent to participate is not available as it was a retrospective analysis conducted after institutional ethical approval.

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

Author details

¹Department of Anesthesia, Lady Hardinge Medical College, New Delhi, India.

²Department of Pediatric Surgery, Lady Hardinge Medical College, New Delhi, India.

³Department of Pediatrics, Lady Hardinge Medical College, New Delhi, India.

⁴Department of Pediatric Surgery, Ram Manohar Lohiya Hospital, New Delhi, India.

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