Fast-track extubation after modified Fontan procedure

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Objective: In 2007, we introduced a policy to plan to extubate all patients after a modified Fontan procedure in the operating room. Our objective was to review the feasibility, safety, and clinical outcomes of this approach.

Methods: Patients who underwent a modified Fontan operation between May 2004 and May 2010 were reviewed.

Results: Ninety-seven patients underwent a modified Fontan operation (mean age, 3.9 ± 2.2 years; mean weight, 15.1 ± 5.0 kg); 46 patients (47%) were extubated in the operating room (group A). Nineteen patients were extubated in the intensive care unit within 24 hours (group B), and 32 patients had delayed extubation (group C). The 3 groups were not significantly different with respect to preoperative characteristics. Twenty-four hours postoperatively, group A had a lower mean central venous pressure compared with patients in group B or C (13 vs 14 vs 17 mm Hg, respectively, $P < .001$); a higher base excess (0.4 vs -1.3 vs -3.4 , $P < .001$); a lower fluid balance (234 vs 514 vs 730 mL, $P < .001$); and a lower inotrope score (4.6 vs 6.7 vs 10.8 , $P < .001$). Group C had a longer median intensive care unit length of stay (2 vs 3 vs 6 nights, $P = .01$), kept their chest tubes longer (8 vs 9 vs 15 days, $P = .001$), and had a longer median hospital length of stay (9 vs 11 vs 21 days, $P = .001$).

Conclusions: Extubation in the operating room after a modified Fontan procedure seems feasible. This approach is associated with improved early postoperative hemodynamics, earlier time to chest tube removal, and shorter intensive care unit and hospital lengths of stay. (*J Thorac Cardiovasc Surg* 2012;144:547-52)

The advantages of an early extubation strategy after pediatric cardiac surgery have been described for a variety of cardiac lesions. These benefits include fewer pulmonary complications, shorter hospital and intensive care unit (ICU) lengths of stay, and reduction in costs and resource use.¹⁻³ In patients with right-sided heart bypass for single ventricle palliation, early extubation may confer a physiologic advantage. Positive intrathoracic pressure has deleterious effects on pulmonary blood flow and hemodynamics.^{4,5} Avoiding prolonged intubation and positive pressure ventilation by allowing spontaneous breathing may mitigate these negative effects.

In 2007, we introduced a fast-track extubation (FTE) strategy to extubate patients after a modified Fontan

procedure in the operating room (OR). The purpose of this study was to retrospectively review all patients undergoing modified Fontan procedures and to determine whether FTE is feasible and associated with improved hemodynamic and clinical outcomes.

PATIENTS AND METHODS

This study was approved by the Health Research Ethics Board of the University of Alberta. We conducted a retrospective review of patients undergoing a modified Fontan operation at the University of Alberta and Stollery Children's Hospitals between May 2004 and May 2010. Patients for Fontan revision were excluded. Ninety-seven patients were included in the study cohort. Forty-six patients (47%) were extubated in the OR (group A), and 51 patients (53%) were extubated in the ICU. In the ICU group, 19 patients were extubated within 24 hours (group B) and 32 patients had delayed extubation (group C).

Fast-Track Extubation Strategy

Before 2007, all patients undergoing a modified Fontan operation arrived in the ICU intubated. Timing of extubation was determined by the clinical course and the judgment of the treating team. In 2007 we introduced the FTE strategy, the intent being to extubate all patients in the OR. Only those with unstable hemodynamics, impaired respiratory effort, significant chest tube bleeding, hypothermia, upper airway edema, or impaired level of consciousness have been left intubated.

Anesthetic Management for Fast-Track Extubation

The anesthetic management of patients was not restricted by protocol and was therefore variable depending on the preferences of the individual anesthesiologist. Anxious children were premedicated with oral midazolam. Induction was via inhalational or intravenous routes. Maintenance

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Abbreviations and Acronyms

AVVR	= atrioventricular valve regurgitation
CVP	= central venous pressure
FTE	= fast-track extubation
ICU	= intensive care unit
LOS	= length of stay
OR	= operating room
PICU	= pediatric intensive care unit

of anesthesia included volatile anesthetic, muscle relaxant, and narcotic infusion. All patients received tranexamic acid. At sternal closure, intercostal nerve blocks or infiltration of the wound was performed with a solution of 0.25% bupivacaine with 1:100,000 dilution of epinephrine. Before emergence, low-dose morphine was judiciously titrated. Antiemetics were routinely used. Ketorolac was used only in patients in whom hemostasis was judged to be excellent.

Surgical Procedure

Through a reoperative median sternotomy and after heparinization with 300 U/kg, the ascending aorta, superior vena cava, and inferior vena cava were cannulated and full cardiopulmonary bypass was established. Ventricular fibrillation was used for an extracardiac or intra-extracardiac Fontan procedure. Cardioplegic arrest was used for a lateral tunnel Fontan operation and the patients who needed an intracardiac repair. The type of procedure (Fontan or lateral tunnel) was chosen by the attending surgeon. After weaning of cardiopulmonary bypass, modified ultrafiltration was performed in all patients. Heparin was reversed with protamine. The final decision to pursue extubation in the OR was made by the attending surgeon and anesthesiologist.

Pediatric Intensive Care Unit Management

Immediate postoperative management for stable patients extubated in the OR included maintenance of inotropic support, especially milrinone, and provision of supplemental oxygen. Analgesia was provided with low-dose morphine infusion, bolus morphine, acetaminophen, and nonsteroidal anti-inflammatory agents. Anxiolytics were occasionally used, and antiemetics were used routinely. Oral intake was permitted after 4 to 6 hours. Parental presence was encouraged as early as feasible.

Statistical Methods

The baseline characteristics among the 3 extubation groups (group A extubated in the OR, group B extubated within 24 hours in the ICU, and group C extubated >24 hours in the ICU) were summarized and differences were compared using analysis of variance for all the comparisons between means of the groups for continuous variables and chi-square tests for categorical variables. Kruskal-Wallis was used for variables that were not normally distributed. By using backward elimination, logistic regression modeling was used to determine variables predictive of early extubation. These variables included sex, weight, age, preoperative hemoglobin, central venous pressure (CVP) pre-extubation, systolic and diastolic blood pressures pre-extubation, ventricular dysfunction, atrioventricular valve regurgitation (AVVR), systemic ventricular morphology (left or right), hypoplastic left heart syndrome (yes/no), type of Fontan, cardiopulmonary bypass time, and crossclamp time. By using backward elimination and the previously noted independent variables, general linear modeling was used to determine the independent effect of the extubation group on (1) fluid balance at 24 hours, (2) time to last chest tube removal, (3) inotrope score at 1 hour, (4) inotrope score at 24 hours, (5) length of stay (LOS) in the ICU, and (6) total hospital

LOS. Inotrope score was calculated using a scoring system described.^{6,7} All analyses were conducted with the Statistical Package for the Social Sciences (SPSS Inc, Chicago, Ill).

RESULTS

Patient Demographics and Preoperative/Operative Characteristics

The proportion of patients undergoing a Fontan procedure and extubated in the OR (FTE) has increased since 2007 (Figure 1). The preoperative and intraoperative characteristics of group A (FTE), group B (extubated within 24 hours), and group C (extubated >24 hours) are summarized in Table 1. There were no significant differences in these characteristics among the 3 groups.

Operative Procedures

Some 98% of all the patients had been staged with a bidirectional cavopulmonary connection. For the modified Fontan procedure, 32 patients had lateral tunnels, 62 patients had extracardiac conduits, and 3 patients had intra-extracardiac conduits. Fenestration was performed in 85% of the patients and was similar among the groups. Concomitant procedures included atrioventricular valve repair performed in 3 patients (6.5%) in group A, 3 patients (15.8%) in group B, and 5 patients (15.6%) in group C. Mean cardiopulmonary bypass and aortic crossclamp times were similar among the 3 groups (Table 1).

Perioperative Hemodynamics

There were no significant differences in preoperative CVP and blood pressure among the 3 groups (Table 2). One hour after patients arrived in the ICU, CVP was significantly lower and blood pressure was significantly higher in group A. After 24 hours in the ICU, group A had a significantly lower CVP, higher base excess, lower inotrope score, and lower lactate.

After 24 hours in the ICU, group B had a lower CVP, lower inotrope score, lower lactate, and lower fluid balance when compared with group C (Table 2), although these were not as good as in group A.

Clinical Outcomes

There was 1 operative death in the entire cohort. The death was not directly attributable to the extubation. This patient was extubated in the OR, reintubated because of bleeding, and reexplored. He required ventricular assist support and died as a result of abdominal sepsis from intestinal ischemia, perhaps related to the assist device, 70 days after the Fontan operation. He had been listed for cardiac transplantation. There were no operative deaths in groups B or C. In groups B and C, there was 1 Fontan take-down. One patient was listed for transplant in group B, and 3 patients have undergone transplantation in group C.

FIGURE 1. Proportion of patients extubated in the operating room and within 24 hours after arrival to intensive care unit. *FTE*, Fast-track extubation (extubation in the operating room).

Four patients were reintubated in group A, including the one who died. Three of these patients were reintubated because of bleeding or tamponade that required reexploration within the first 24 hours. The fourth patient was reintubated after 5 days because of seizures. None of these complications were attributable to extubation. Two patients were reintubated in group B, of whom 1 had reexploration for bleeding and 1 had sepsis. Five patients were reintubated in group C because of respiratory distress. There was no significant difference in reintubation rates among the 3 groups ($P = .63$). For purposes of the analyses, the reintubated patients remained in the treatment groups to which they were originally assigned.

There were no differences in the reexploration rates for bleeding among the 3 groups (8.7% in group A, 5.3% in group B, 9.4% in group C; $P = .86$). Clinical low cardiac output occurred more frequently in group C (2.2% in group A, 0% in group B, 25.0% in group C; $P = .001$). A higher incidence of dysrhythmias with sinus dysfunction and

junctional ectopic tachycardia was present in group C (6.5% in group A, 5.3% in group B, 25.0% in group C; $P = .03$), with 3 patients requiring permanent epicardial pacemakers in that group. There were no significant differences in the occurrence of chylothorax, stroke, and infection among the 3 groups.

Fluid balance after 24 hours in the ICU was significantly lower in group A (Table 2). Duration of ICU stay, time to last chest tube removal, and total hospital LOS were significantly lower in group A. Nevertheless, group B had a shorter time to chest tube removal and hospital LOS compared with group C.

Predictors of Outcomes

In multivariable analysis, higher preoperative hemoglobin was associated with successful extubation in the OR (odds ratio, 1.04; 95% confidence interval, 1-1.07). Also, patients with more than moderate AVVR preoperatively were less likely to be extubated in the OR (odds ratio, 0.24; confidence interval, 0.07-0.91). The use of the lateral tunnel was strongly associated with extubation in the OR (odds ratio, 3.63). However, this may be related to the association of the use of the lateral tunnel by the surgeon who initiated the practice of extubation in the OR. In the most current year, the proportion of patients extubated in the OR is similar among all surgeons.

Among other variables, extubation in the OR was independently associated with a lower inotrope score at 1 and 24 hours after arrival in the ICU, fewer nights in the ICU, lower 24-hour fluid balance, earlier chest tube removal, and lower hospital LOS (Table 3).

DISCUSSION

We observed that extubation in the OR after a modified Fontan operation is feasible. Compared with patients who were extubated later in their ICU course, patients receiving FTE were associated with improved hemodynamics, lower inotrope score, and lower fluid balance in the ICU. Extubation in the OR also was associated with a shorter LOS in the ICU, shorter time to chest tube removal, and shorter hospital LOS. FTE in the OR was an independent predictor of lower fluid balance and inotrope score at 24 hours, and less time to chest tube removal and lower LOS in the ICU and hospital. In addition, extubation within 24 hours after arrival in the ICU seemed to be associated with some benefit.

The importance of spontaneous ventilation in a Fontan circuit has been recognized for some time. In 1991, Redington and colleagues⁴ described pulmonary blood flow patterns using Doppler echocardiography in 3 patients after total cavopulmonary shunt procedures. Pulmonary blood flow was increased with normal inspiration and the Mueller maneuver and decreased during the Valsalva maneuver. Ventricular dimensions reflected the latter changes. They concluded that pulmonary blood flow changes with

TABLE 1. Preoperative and intraoperative characteristics

Variable	Group A n = 46	Group B n = 19	Group C n = 32	P value
Age (y)	4.2 ± 2.6	4.2 ± 2.6	3.4 ± 0.9	.34
Weight (kg)	15.6 ± 6.1	15.7 ± 5.3	13.9 ± 5.0	.27
Sex (male) (%)	54.3	68.4	62.5	.13
Systemic right ventricle (%)	65.2	52.6	78.1	.16
HLHS (%)	43.5	52.6	46.9	.80
Hb (g/L)	170 ± 15	165 ± 17	162 ± 21	.13
mPAP (mm Hg)	10.2 ± 2.5	10.7 ± 2.8	11.6 ± 2.8	.11
Sao ₂ (%)	83.7 ± 4.3	83.7 ± 3.0	83.6 ± 4.8	.99
Moderate or greater systolic dysfunction (%)	4.3	0	6.2	.55
AVVR ≥ moderate (%)	10.9	15.8	25.0	.25
CPB time (min)	92.2 ± 22.4	89.2 ± 19.5	94.2 ± 18.6	.65
Crossclamp time (min)	28.5 ± 21.0	17.3 ± 23.6	21.9 ± 28.8	.27

HLHS, Hypoplastic left heart syndrome; *Hb*, hemoglobin; *mPAP*, mean pulmonary artery pressure; *Sao₂*, systemic saturation; *AVVR*, atrioventricular valve regurgitation; *CPB*, cardiopulmonary bypass.

TABLE 2. Postoperative variables before extubation and 1 and 24 hours after arrival to intensive care unit, and other clinical outcomes

	Group A, n = 46	Group B, n = 19	Group C, n = 32	P value
Pre-extubation				
CVP (mm Hg)	17.3 ± 2.3	17.1 ± 2.8	17.3 ± 1.9	.932
Systolic BP (mm Hg)	87.0 ± 9.7	89.4 ± 13.9	94.2 ± 18.6	.09
Diastolic BP (mm Hg)	47.4 ± 6.2	46.8 ± 6.9	49.4 ± 10.6	.43
1 h				
CVP (mm Hg)	12.8 ± 2.6	16.0 ± 3.3	17.4 ± 2.6	<.001
CAP (mm Hg)	6.8 ± 3.0	6.4 ± 3.5	9.2 ± 4.0	.01
Systolic BP (mm Hg)	91.0 ± 12.3	87.1 ± 9.5	82.8 ± 11.7	.011
Diastolic BP (mm Hg)	49.1 ± 7.1	46.6 ± 7.7	44.1 ± 4.8	.013
Pao ₂ (mm Hg)	73.5 ± 20.6	67.4 ± 28.9	67.8 ± 22.5	.46
Paco ₂ (mm Hg)	44.2 ± 5.2	44.4 ± 4.8	45.3 ± 6.3	.68
Base excess	-1.1 ± 4.7	-2.7 ± 4.5	-2.9 ± 4.4	.19
pH	7.30 ± 0.05	7.29 ± 0.04	7.28 ± 0.05	.3
Hb (g/L)	138 ± 21	140 ± 11	139 ± 21	.93
Inotrope score	9.7 ± 10	7.8 ± 5.7	9.5 ± 8.5	.72
24 h				
CVP (mm Hg)	12.8 ± 2.5	14.1 ± 2.0	16.7 ± 2.5	<.001
CAP (mm Hg)	6.8 ± 4.4	6.7 ± 4.0	9.6 ± 3.8	.02
Systolic BP (mm Hg)	93.5 ± 11	100.0 ± 12	84.6 ± 9.7	<.001
Diastolic BP (mm Hg)	53.6 ± 6.6	55.4 ± 8.1	47.5 ± 6.6	<.001
Pao ₂ (mm Hg)	70.4 ± 27.1	56.2 ± 11.0	64.5 ± 19.6	.07
Paco ₂ (mm Hg)	40.7 ± 4.6	40.9 ± 5.3	40.9 ± 5.2	.99
Base excess	0.4 ± 2.9	-1.4 ± 3.2	-3.4 ± 3.7	<.001
pH	7.38 ± 0.05	7.36 ± 0.05	7.32 ± 0.04	<.001
Hb (g/L)	130 ± 19	135 ± 18	133 ± 17	.59
Inotrope score*	0.0 (0, 16)	6.0 (0, 20)	10 (0, 40)	<.001
Blood product transfusion (%)*	33	26	53	.09
Fluid balance (mL)*	216 (-283, 1010)	512 (-24, 1353)	806 (411, 1906)	<.001
Highest lactate*	3.4 (1.3, 5.9)	4.1 (1.9, 9.1)	4.1 (1.7, 10.7)	.001
Outcomes				
Hours to extubation*	0 (0)	16 (4, 24)	129 (28, 2400)	<.001
Last chest tube removal* (d)	8 (4, 62)	9 (2, 44)	14 (5, 45)	<.001
Nights in ICU*	2 (1, 70)	9 (1, 12)	10 (3, 208)	<.001
LOS in hospital (d)*	9 (6, 70)	11 (5, 57)	21 (9, 217)	.001

Values given as means and standard deviations for normally distributed variables. CVP, Central venous pressure; BP, blood pressure; CAP, common atrial pressure; Pao₂, arterial oxygen tension; Paco₂, alveolar carbon dioxide tension; Hb, hemoglobin; ICU, intensive care unit; LOS, length of stay. *Parameters were not normally distributed and are given as medians (minimum, maximum).

conditions that alter intrathoracic pressures. The authors suggested that patients undergoing the Fontan procedure may benefit from minimizing positive end-expiratory pressure and mean airway pressures. It follows that the optimal ventilatory condition for patients after the Fontan operation would be spontaneous ventilation. This is the rationale behind early extubation of these patients. We have extended this approach to extubation in the OR to maximize the benefits of spontaneous ventilation.

For the patients undergoing the Fontan procedure, the additional potential benefits of early extubation include avoidance of prolonged mechanical ventilation and its complications, such as laryngotracheal trauma, accidental extubation, oversedation, pulmonary infections, pulmonary hypertensive crisis by tracheal suctioning, mucus plugging, and atelectasis, and unfavorable cardiopulmonary interactions with detrimental effects of increased intrathoracic

pressure on ventricular filling or afterload.⁸ However, delayed extubation may have the advantage of easier management of postoperative problems. If a patient becomes unstable or has a cardiac arrest, the airway is already secure and ventilation or oxygenation can be adjusted readily. Without worry of airway maintenance or hypoventilation, patient agitation can be more easily controlled with sedation and pain can be more aggressively treated. We believe that the potential benefits of early extubation, even in the OR, outweigh the potential advantages of delaying extubation. It is therefore our practice now to assume that every patient undergoing a modified Fontan operation can be extubated at the end of the case.

We observed that a higher preoperative hemoglobin and less preoperative AVVR were associated with FTE, although the association was weak. Patients with higher preoperative hemoglobin may have been less anemic coming

TABLE 3. Independently associated predictors of inotrope score, fluid balance, time to last chest tube removal, and hospital and intensive care unit length of stays

Lower inotrope score at 1 h	
Mild or less ventricular systolic dysfunction	$P < .001$
Lower inotrope score at 24 h	
FTE vs later extubation	$P < .001$
Older age	$P = .01$
Greater weight (kg)	$P = .022$
Lower CVP pre-extubation (mm Hg)	$P = .016$
Higher systolic BP pre-extubation (mm Hg)	$P = .01$
Lower fluid balance/kg at 24 h	
FTE vs later extubation	$P < .001$
Shorter CPB time (min)	$P = .04$
Lower CVP preoperatively (mm Hg)	$P = .04$
Fewer nights in ICU	
FTE vs later extubation	$P = .034$
Higher Hb preoperatively	$P = .039$
Shorter CPB time (min)	$P = .043$
Shorter time to last chest tube removal	
FTE vs later extubation	$P = .006$
Shorter CPB time (min)	$P = .035$
Shorter crossclamp time (min)	$P = .006$
Shorter hospital LOS	
FTE vs later extubation	$P = .006$
Higher preoperative Hb	$P = .028$
Shorter CPB time (min)	$P = .032$

FTE, Fast-track extubation (extubation in OR); CVP, central venous pressure; BP, blood pressure; CPB, cardiopulmonary bypass; ICU, intensive care unit; Hb, hemoglobin; LOS, length of stay.

off bypass with higher oxygen saturations and therefore more likely to be extubated. The decision to extubate at the end of the Fontan procedure is made in concert by the surgeon and anesthesiologist. The complexity of the procedure is becoming less of a factor in the decision to extubate or not. We noted that crossclamp or cardiopulmonary bypass times were not predictive of FTE. In patients with higher pulmonary artery pressures, early extubation may be used as a strategy to reduce pulmonary vascular resistance in these higher-risk patients and may not be a contraindication to early extubation.⁹ Intraoperative factors that weigh into our decision to extubate include the degree of inotropic support and the amount of bleeding or chest tube losses.

Four patients in our FTE group (group A) had to be reintubated; 3 of these were reintubated because of bleeding or tamponade. This finding emphasizes the need to obtain meticulous surgical hemostasis and to aggressively treat coagulopathy in the OR. This may require a period of observation in the OR before deciding to extubate and transferring the patient to the ICU.

The hemodynamics we observed of lower CVP and higher 1-hour blood pressure in Fontan cases after extubation in the OR has been described by Morales and colleagues.¹⁰ Likewise, they report a lower inotrope support in their extubated cohort. In their experience of 112 patients, they also observed a shorter ICU and hospital LOS

for their extubated patients. They performed a brief cost analysis based on the savings related to ICU and hospital LOS and found a financial benefit to early extubation.

In 2001, Lofland⁵ reported on his experience of 50 consecutive patients after a Glenn or Fontan procedure who were managed with early extubation in the OR or within 1 hour postoperatively. After extubation, he observed a significant reduction in mean pulmonary artery pressure (CVP) in the entire cohort and a significant improvement in cardiac index in a subgroup. He emphasized the importance of the intraoperative anesthetic and postoperative pain management. Of note, postoperative pain management included patients with epidural blocks or hyperbaric spinal only. Others received fentanyl and versed as needed.

Kurihara and colleagues¹¹ reviewed 77 patients extubated within 3 hours after right-sided heart bypass (Glenn and Fontan) and found that the early extubation group had fewer respiratory complications and a shorter pediatric intensive care unit (PICU) LOS. Patients who were extubated earlier had lower preoperative pulmonary artery pressures, lower intraoperative fentanyl dosing, and lower postoperative inotropic scores on admission to PICU. However, there were few, if any, early hemodynamic benefits in the early extubation group. In contrast to this report, hemodynamic improvements with early extubation, lower CVP and left atrial pressure, and higher systemic body pressure were observed in the current study. We believe that the benefits of early extubation may be related to improved hemodynamic performance in this group, in addition to the salutary pulmonary benefits of being extubated.

The benefits of early extubation in children undergoing cardiac operations for a variety of lesions are well documented. A recent meta-analysis looked at the evidence around early extubation after congenital heart surgery.¹ The authors identified 9 studies that met their eligibility criteria. There was only 1 randomized trial. The groups in these studies had a variety of cardiac conditions. Patients who were extubated in the OR or within 6 hours of surgery had associated lower early mortality, with trends toward shorter ICU and hospital LOS, lower hospital costs, and less respiratory morbidity.

Various defined, early extubation may be extubation in the OR or before some predetermined time after arrival in the ICU.¹² We observed that for the clinical outcomes of time to chest tube removal and hospital LOS, extubation in the OR seemed advantageous compared with early extubation in the ICU. Waiting to extubate patients in the OR may lead to delays between operative cases. Extubating early in the ICU may be more efficient if it can be demonstrated that such an approach can confer similar benefits.

The importance of good anesthetic and postoperative pain management cannot be overstated. The success of extubation in the OR or soon after arrival to the PICU highly depends on proper anesthetic and PICU planning and

practice. Too much sedation or narcosis may lead to hypoxemia, hypercarbia, and atelectasis, which will increase PVR and compromise pulmonary blood flow. Pain will cause splinting and atelectasis, with similar effects. At the University of Alberta, epidural or spinal blocks are not used. Adjuncts to pain management in our patients include wound infiltration with local anesthetic and intravenous ketorolac. We have observed that intercostal nerve blocks performed under direct vision before sternal closure are more effective than simple wound infiltration with local anesthetic. In addition, we try to bring the parents or primary caregivers to the patient's bedside as soon as feasible and encourage them to stay with their child. We have found that their presence has a calming effect and may reduce the need for anxiolytics. We have 5 pediatric cardiac anesthesiologists, and the anesthetic management of patients undergoing the Fontan procedure is not standardized, suggesting that more than 1 approach to FTE can be successful.

Study Limitations

Our study is retrospective and observational, with a small number of patients from a single institution over a 6-year period. To minimize time-related bias, we included all contemporaneous patients, beginning at the time the practice extubation in the OR was started.

Because our study is not a randomized trial, we acknowledge that there is a selection bias toward extubating more stable patients in the OR. The decision to extubate the patients in the OR was not based on a predetermined protocol and was based on the discussion between, and clinical judgment of, the attending surgeon and the anesthesiologist, and is therefore difficult to quantify. Factors contributing to the decision would include the complexity of the procedure, the stability of the patient, and the amount of bleeding. Nevertheless, as the practice evolved, more and more patients have been extubated successfully, despite previous apparent concerns.

CONCLUSIONS

Extubation in the OR after a modified Fontan procedure seems feasible. This approach is associated with improved early postoperative hemodynamics, earlier time to chest tube removal, and shorter ICU and hospital lengths of stay.

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