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Discussion

Strategy of early postoperative recovery following pediatric cardiac surgery

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ABSTRACT

Pediatric cardiac surgery involves procedures performed on the some of the most physiologically complex and vulnerable patients. The post-bypass period is especially fraught with life-threatening episodes of malignant arrhythmias, low cardiac output states and excessive hemorrhage. We herein propose a strategy of continuing care in the operating room at the termination of the procedure.

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1. Introduction

Complex surgery of any type leaves patients potentially susceptible to an unstable hemodynamic state and compromised oxygen delivery due to a variety of causes. This is especially true for children undergoing complex congenital heart surgery. Postoperative compromise of cardiac function post-cardiopulmonary bypass, alterations in systemic vascular resistance (SVR), postoperative coagulopathy and bleeding, and altered respiratory function may contribute to the vulnerability of these children in the early postoperative state. If these alterations are not aggressively addressed, the potential detrimental outcomes may be severe, including profound hemodynamic compromise, acidosis, cardiogenic shock, and ultimately cardiac arrest.

A common practice in congenital heart surgery is to transport post-cardiac surgery children from the operating room (OR) to the pediatric intensive care unit (PICU) as soon as the surgery has been completed. During this time, the cardiac anesthesia team focuses on the transport, while the PICU team receiving the patient may require some time to perform the initial patient assessment and institute the appropriate care. This process may be problematic, as it exposes the patient to the transport and initial PICU assessment during a potentially vulnerable post-cardiac surgery physiological state, in which expeditious interventions may have to be provided to correct the physiological alterations.

The aim of this article is to describe the advantages of a care delivery and early resuscitation model in which the initial management of the patient following congenital heart surgery is carried out in the operating room for a selected and individualized period of time, prior to transitioning the care to the pediatric ICU. This model is individualized to best suit congenital heart surgery patients primarily based on operative complexity and pathophysiological state during and after heart surgery. The rationale for this strategy is to be able to deliver nearly instantaneous care and appropriate interventions in response to a variety of potentially life-threatening physiological states in a period of maximal physiological vulnerability. This care delivery model may be especially beneficial in low to medium volume congenital cardiac surgery programs, where early resuscitation in the ICU following heart surgery may not offer the benefits of resuscitation in the OR for a variety of reasons discussed below.

2. Patient selection criteria and description of strategy

We outline our practice of immediate post-procedural for any patient who has hemodynamic instability or marginal pulmonary function. Neonates are the most common group of patients for whom we employ this plan since they seem to have the greatest number and degree of physiological fluctuations. We utilize this approach with any patient who requires increasing inotropic or

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vasoactive support or whose needs for volume resuscitation fail to decrease or plateau. A pH of <7.25 with adequate ventilation ($PaCO_2$ < 50 mmHg) and/or a rising lactate (lactate > 3 mmol/L) also triggers a prolonged stay at the end of the case. Marginal oxygenation with a SaO_2 of <90% in patients with non-cyanotic heart disease or <75% in patients with cyanotic heart disease using an FiO_2 of 1.0 is the lower limit of what we tolerate for a safe transport and so delay departure from the OR.

Borderline systolic or diastolic function will be carefully observed for signs of any deterioration. The ability of anesthesia providers to interpret the data from the echocardiogram is very valuable. Life-threatening dysrhythmias are also a significant trigger to delay exit from the OR. We find it useful to initiate aggressive therapy in the operating room especially for junctional ectopic tachycardia (JET). Prior to chest closure, we closely watch for any signs of coagulopathy and remain in the operating room and treat accordingly. We will draw blood and run a thromboelastogram (TEG) if there is any suspicion of inadequate coagulation and doggedly correct all abnormalities if found. We solely rely on TEG because in our institution it provides the fastest results. If rapidly available we recommend that fibrinogen level should be at least 150 mg/dL, platelet count be at least 100,000 per micro-liter, Thrombin time lowered below 16 seconds and Partial thromboplastin time below 40 seconds. Keep International normalized ratio below 1.5. Our threshold to keep the sternum separated is low particularly in the neonatal population. After the chest thoracostomy tubes are placed on suction which we carefully observe for an output greater than 4 mL/kg/hour. Lastly, either the anesthesiologist or surgeon may trigger this strategy. Fig. 1 describes the strategy. Once initiated by one or both intraoperative physicians (surgeon and/or anesthesiologist) the major determinant of what to do next depends on the cause. If on-going bleeding is deemed to be excessive then the chest is explored. If the cause for instability is ongoing cardiac or pulmonary dysfunction then the patient is not allowed to go to the ICU until stability is restored through careful medical management (sometimes with input elicited from cardiology and/or our intensive care colleagues) or institution of mechanical support with ECMO. Criteria for initiation of ECMO includes a poor systolic and/or diastolic cardiac function that causes a continuing threat to life, pulmonary hypertension that threatens oxygenation and/or right heart function (that is refractory to conventional treatment), malignant arrhythmias resistant to treatment or isolated severely impaired pulmonary function that impedes adequate ventilation and oxygenation.

3. Advantages of early resuscitation in the OR

There are numerous advantages to this strategy including allowing the same staff (physicians and nurses) to continue to care for patients during their most vulnerable state. Ancillary support staff (such as radiology, surgery and anesthesia technologists) and perfusionists are immediately available. Surgical equipment for immediate re-exploration is also readily available along with the equipment to sterilize and/or re-sterilize surgical instruments. Major undertakings such as ECMO cannulation and initiation are much easier in the OR. Operating room environments allow the OR team to titrate vasoactive and intropic drugs rapidly without having to electronically enter or write orders, and then relay the order to a mid-level provider or nurse for implementation. Inhaled drugs, particularly Nitric Oxide, can also be rapidly titrated to the desired effect without the need for a respiratory therapist, if the anesthesia providers are so trained. We highly recommend that anesthesia personnel be trained to use the Nitric Oxide delivery system. In our opinion, responses to major respiratory events such endotracheal

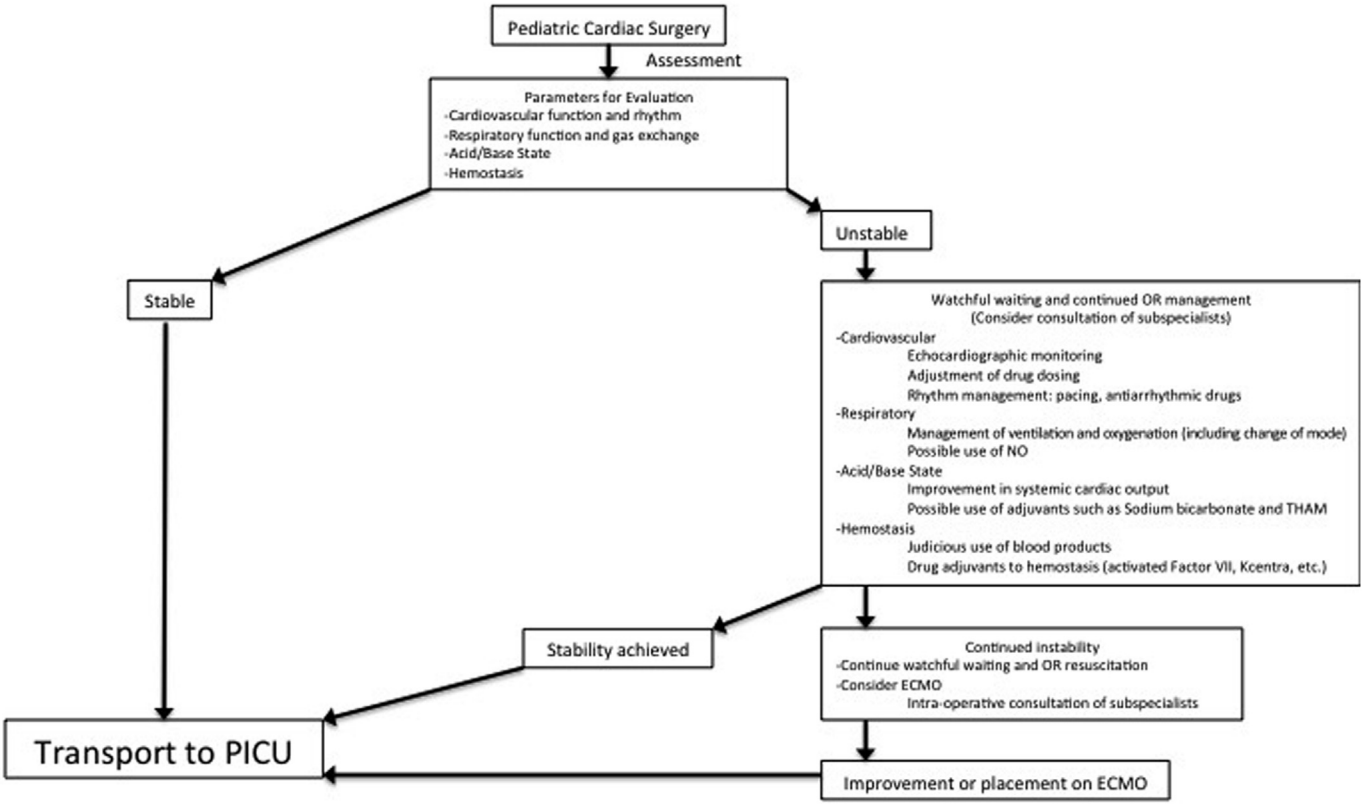

Fig. 1. The flow chart outlines the decision algorithm prior to transport to the ICU. It is paramount to consider cardiovascular, respiratory, acid/base and hemostatic status.