Delayed sternal closure: a life-saving measure in neonatal open heart surgery; could it be predictable?

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Abstract

Objectives: The tight syndrome after open-heart procedures in neonates renders delayed sternal closure (DSC) a life-saving measure. The goal of this study is to analyze the risk factors that may predict the need for DSC.

Methods: Between January 1991 and December 2000, 312 consecutive open-heart procedures in neonates (180 males, 132 females) were studied retrospectively. Median age was 11.9 days (range 1–30 days) and weight 3.63 kg (range 1.8–4.2 kg). The major pathologies were transposition of the great arteries (153), interruption of the aortic arch (IAA) (33), total anomalous pulmonary venous drainage (TAPVD) (24) and single ventricle (19). Two hundred and twenty-eight patients had profound hypothermia with circulatory arrest and 74 normothermic cardiopulmonary bypass (CPB), 195 had crystalloid cardioplegia and 111 blood cardioplegia. Median CPB time was 146 min (range 37–284 min) and aortic clamping 67.6 min (range 0–164 min). Two hundred and fifty-five patients had a continuous ultrafiltration and 57 had a modified ultrafiltration. The criteria for DSC were hemodynamic instability, deterioration of the central venous saturation, metabolic status and/or high ventilatory pressures.

Results: One hundred and nineteen patients had DSC (38.12%). Median CPB time was 145 min (range 37–284 min) and aortic clamping time 67.6 min (range 0–164 min). Twenty-one patients (6.7%) needed reopening in the intensive care unit (ICU) during the first 24 h. Among the studied factors, the age below 7 days (P = 0.014), the diagnosis of IAA and TAPVD (P < 0.05), CBP duration over 185 min (P = 0.048), clamping time over 98 min (P = 0.039) and central venous saturation below 51% (P = 0.024) were statistically significant risk factors. All the patients who had more than 106 min of clamping, more than 196 min of cardiopulmonary bypass or less than 47% of central venous saturation were either left opened or reopened in the ICU.

Conclusions: Many of the factors thought to be associated with the need for delaying the sternal closure had no statistical significance as risk factors. On the other hand, the diagnosis of IAA or TAPVD, an age less than 7 days, aortic clamping more than 98 min, CPB time more than 185 min and a post-bypass central venous saturation less than 51% were statistically significant risk factors that could be used in predicting the need for delaying the sternal closure. © 2002 Elsevier Science B.V. All rights reserved.

Keywords: Sternal closure; Neonate; Risk factors; Objective criteria; Prediction; Cardiac surgery

1. Introduction

Sternal closure after open-heart procedures represents sometimes a critical decision especially in the neonatal community. Since the first suggestion of sternal suspension or delaying the sternal closure in the mid-1970s, many surgeons had become either for or against the idea [1]. In all cases the decision is being taken depending on more or less personally based criteria that can be considered subjective. All pediatric cardiac surgeons can also recognize the need for certain cases to be reopened on an emergency basis and sometimes in a catastrophic condition in the immediate postoperative period despite the relative hemodynamic stability during and immediately after sternal closure. It is also very easy to recognize the increased morbidity and mortality of this group of patients when compared with those left with their chest opened. The application of the technique varies among different centers to the degree that while a few centers delay the sternal closure routinely either in all neonates or for certain pathologies, others do not apply the technique except after repetitive failed trials to close
sternum. We can also see that after all the advances in postoperative management; the technique of delaying the chest closure carries no or negligible additional risk to the patient [2]. From all of this and after more than 25 years of the introduction of the technique, we find ourselves with a need to verify the real risk factors for delayed sternal closure in order to be able to predict, at the end of the operation, the need for delaying the sternal closure.

The main aim of this work is to render the decision of sternal closure more objective and more or less predictable. To achieve this aim we had two goals:

1. Studying a group of factors thought to be associated with the need for delayed sternal closure in neonates after open heart procedures to verify the actual risk factors
2. The establishment of objective criteria that might help in the decision making for sternal closure

2. Patients and methods

Between January 1991 and December 2000, 335 neonates successively underwent open-heart operations in the Department of Thoracic and Cardiovascular Surgery, La Timone Children’s Hospital, Marseille, France (a regional referral center based in an urban university teaching hospital). The 23 patients who had intraoperative mortalities or incomplete files were excluded from the study. The medical records of the remaining 312 patients form the raw data for this report (a retrospective study). The patients’ age ranged from 14 h to 30 days with a median of 11.9 days, and their body weight ranged from 1.85 to 4.65 kg with a median of 3.63 kg. The major pathologies were transposition of the great arteries (TGA, 153 patients, 49%), interruption of the aortic arch (IAA, 33 patients, 10.6%) and total anomalous pulmonary venous drainage (TAPVD, 24 patients, 7.7%).

The characteristics of our group of patients are listed in Table 1 and the studied variables in Table 2.

2.1. Definitions of terms

Primary sternal closure (PSC) is the closure of the patient’s sternum at the end of the operation.

Delayed sternal closure (DSC) is leaving the chest opened for some time by delaying the closure of the sternum, and we can distinguish two types of DSC:

1. Primary delayed sternal closure (PDSC) is delaying the sternal closure either as a principal method or after failure of one or several trials of closure at the end of the operation
2. Secondary delayed sternal closure (SDSC) is the closure of the sternum that was primarily closed at the end of the operation and was reopened during the early postoperative period

The analyzed variables we thought were the factors most suspected to be associated with the need for DSC are listed in Table 2.

2.2. Conduct of cardiopulmonary bypass and myocardial protection

During the period of the study many of the techniques used, either surgical or parasurgical (cardiopulmonary bypass, cardioplegia, ultrafiltration, anesthesia and ventilation) changed sometimes even more than once. All patients operated on had a cardiopulmonary bypass with aortic...
cross-clamping (except three cases with ventricular septal defect and pulmonary atresia in whom opening of the right ventricular outflow tract was performed on cardiopulmonary bypass (CPB) without aortic clamping). The CPB was performed with a basic flow of 2.5 l/min per m². Total circulatory arrest with profound hypothermia at 18°C was used in most of the cases before May 1998 and in selected cases afterwards.

Myocardial preservation was performed by surface cooling (by intermittent irrigation of 4°C cold saline) and anterograde cardioplegic solution. Crystalloid cold cardioplegia was routinely used before February 1999 and after that date we used cold blood cardioplegia with warm induction and repuffusion. The average interval between the cardioplegic doses was about 20 min.

The ultrafiltration was used in all cases. It was conducted throughout the cardiopulmonary bypass except between March 1994 and March 1996, where it was conducted only postbypass (the technique of modified ultrafiltration) [3]. The aim and the conduction of ultrafiltration depended on the type of CPB. In cases of deep hypothermia and circulatory arrest ultrafiltration was used during the rewarming period, aiming at achieving a hematocrit of 25% or more at the end of the cardiopulmonary bypass while in normothermic CPB the goal was a hematocrit above 28%.

On the other hand when modified ultrafiltration was used it was conducted as long as was necessary to raise the hematocrit above 30% and/or to empty the extracorporeal circuit.

2.3. Methods and decision making

PDSC was decided even with out performing a trial of closure in cases of (1) presence of important bleeding of nonsurgical cause, (2) massive increase of the cardiac volume due to myocardial edema or dilatation or after the implantation of a homograft, and (3) need of high ventilatory pressures to maintain acceptable oxygen saturation.

In all other cases a trial of closure was performed. In the trials the following parameters were considered as indicators for the possibility of PSC: (1) the arterial blood gases and metabolic status, (2) the hemodynamic parameters including the heart rate, the systemic arterial pressure, central venous pressure, pulmonary artery pressure, and left atrial pressure, (3) the central venous saturation, and (4) the ventilatory pressures.

After marking all of the above parameters, the chest retractor was gently closed and removed, then the sternal borders were approximated without using any instrument that might express any additional pressure on the chest.

The patient was closely monitored for 15 min; during this period all the parameters were noted every 5 min and the data were compared to those taken before the approximation of the sternal borders. The trial was considered a failure if there was one or more of the following results:

1. A drop in the heart rate, arterial blood oxygen saturation, central venous saturation and/or systemic arterial pressure
2. An increase in the heart rate, left atrial pressure, central venous pressure, pulmonary artery pressure and/or airway pressure
3. The appearance of arterial blood acidosis

In case of failure of the trial the chest retractor was reused and the patient was stabilized. Any correctable factor was managed before performing another trial, otherwise a stent (usually a rigid plastic tube) was fixed in place to keep the chest widely opened and an airtight synthetic transparent patch was used to cover the sternal gap (being fixed to the skin and recently to the subcutaneous tissue to have a more cosmetically acceptable scar later on). An antiseptic ointment was put all around the plaque to close the portal entry of infection as well as the needle holes, to keep the closure airtight.

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Table 2
Variables analyzed from the medical records of 312 neonates who underwent open cardiac procedures at La Timone children’s hospital from January 1990 through December 2000

<table>
<thead>
<tr>
<th>Variable</th>
<th>Units and mode of presentation of the data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>Male/female, No. (%)</td>
</tr>
<tr>
<td>Age</td>
<td>Days, median (range)</td>
</tr>
<tr>
<td>Diagnosis</td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>Kilograms, median (range)</td>
</tr>
<tr>
<td>History of prematurity</td>
<td></td>
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<tr>
<td>History of preoperative mechanical ventilation</td>
<td></td>
</tr>
<tr>
<td>Preoperative average saturation</td>
<td></td>
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<tr>
<td>History of preoperative prostaglandin perfusion</td>
<td></td>
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<tr>
<td>History of preoperative inotropic support</td>
<td></td>
</tr>
<tr>
<td>Cardiopulmonary bypass time</td>
<td></td>
</tr>
<tr>
<td>Total circulatory arrest time</td>
<td></td>
</tr>
<tr>
<td>Aortic cross-clamp time</td>
<td></td>
</tr>
<tr>
<td>Type of ultrafiltration (continuous or partial at the end of bypass)</td>
<td></td>
</tr>
<tr>
<td>Central venous saturation</td>
<td></td>
</tr>
<tr>
<td>Type of cardioplegia</td>
<td></td>
</tr>
</tbody>
</table>
The dressing was changed in the intensive care unit (ICU) in a totally aseptic manner every day and any accumulating effusion was aspirated.

With a minimum of 3 days the indications of performing a trial of DSC were:

1. a stable hemodynamic condition during the last 24 h;
2. a negative total fluid balance;
3. an acceptable coagulation profile; and
4. an improvement of the respiratory dynamics and arterial blood gases.

The trial of closure was identical to the intraoperative trial (after the removal of the plaque and the sternal stent, and taking two mediastinal and pericardial swabs for culture), and was usually performed in the ICU.

In the case of a successful trial the sternum was closed with absorbable sutures and the deep subcutaneous tissue also with absorbable suture. While the rest on the skin were closed with widely separated interrupted mattress nonabsorbable sutures.

Our routine antibiotic prophylaxis was in the form of cefamandole (a second-generation cephalosporine) 50 mg/kg at the induction of anesthesia, 25 mg/kg on the bypass, then switching to vancomycin 10 mg/kg per 8 h in case of DSC until the removal of drains.

2.4. Statistical analysis

The data were compared with a two-tailed paired t-test. Comparisons between groups of unequal populations were achieved with use of a two-tailed unpaired t-test assuming unequal variances or the Wilcoxon rank sum test, or with both tests. Univariate analysis and multivariate logistical regression were used to determine predictors for delayed sternal closure (DSC). A value of $P < 0.05$ was considered significant.

3. Results

A history of prematurity was found in 34 patients (10.9%) and preoperative assisted ventilation in 128 (41%) with a duration median of 2.8 days. Positive inotropic drugs were used preoperatively in 37 patients (11.9%) with a duration median of 5.5 days. Prostaglandin E2 infusion was used in 243 patients (77.9%) with a duration median of 2.6 days. The median of the preoperative oxygen saturation was 83.6%.

Total circulatory arrest with profound hypothermia at 18 °C was performed in 228 patients (73%) and normothermic cardiopulmonary bypass in 74 (27%). Reconstruction of the right ventricular outflow tract in patients with pulmonary atresia and ventricular septal defect was performed on a beating heart in three patients (no aortic clamping).

Crystalloid cold anterograde cardioplegia was used in 195 patients (62.5%) and cold blood anterograde cardioplegia with a warm induction and reperfusion was used in 111 patients (37.5%).

The ultrafiltration was performed throughout the cardiopulmonary bypass in 255 patients and only after the bypass in 57 (18.3%).

The median cardiopulmonary bypass duration was 146 min, ranging from 37 to 284 min and the aortic clamp time ranged from 0 (no clamping) to 164 min with a median of 67.6 min.

At the end of the operation PSC was performed in 193 patients (61.9%), and PDSC in 119 (38.1%). The indication for DSC was the failure of one or more trials of closure in 42 patients (35.3%), increased cardiac volume or myocardial dysfunction with high inotropic support (subjective) in 56 (47%), nonsurgical bleeding in 13 (10.9%) and cardiac arrest before leaving the operating room in eight (6.7%). During the first 24 h postoperatively, 21 of the patients who had a PSC (6.7%) needed sternal reopening (SDSC) due to a syndrome of cardiac pseudo-tamponade (tissue hypoperfusion, hypoxemia, acidosis, increased central venous pressure and oliguria). The indication for reopening was sudden severe hemodynamic impairment in 14 patients, with circulatory arrest in four and cardiac arrest in three.

Statistical regression recognized the age less than 7 days as a risk factor ($P = 0.014$) while the body weight had no statistical risk significance.

Neither the sex, preoperative arterial oxygen saturation, history of prematurity, preoperative inotropic treatment, assisted ventilation nor prostaglandin E2 infusions had statistical risk significance.

The use of total circulatory arrest with profound hypothermia also had no statistical risk significance.

On the other hand, all patients who had a cardiopulmonary bypass duration exceeding 196 min needed to be either left opened in the theater or to be reopened in the early postoperative period. Statistically; a bypass time longer than 185 min was a significant risk factor for DSC ($P = 0.048$).

Aortic clamping time was also a statistical risk factor if exceeding 98 min ($P = 0.039$), and all patients with a clamping time more than 106 min had either DSC or SDSC.

The type of the cardioplegic solution and the mode of ultrafiltration were not a significant risk factor.

The central venous saturation at the end of the cardiopulmonary bypass with the chest retractor in place was a sensitive marker for the liability of closure. All patients who had a central venous saturation less than 47% needed either a PDSC or SDSC, and a central venous saturation less than 51% was a statistical risk factor for DSC ($P = 0.024$).

Among the pathologies in our series, interruption of the aortic arch and total anomalous pulmonary venous drainage were statistical risk factors for PSC ($P = 0.04$, $P = 0.031$, respectively).

The characteristics of patients with DSC are listed in Table 3.

We were unable to study the importance of the high
4. Discussion

Riahi and colleagues were the first who emphasized the importance of sternal closure as a cause of cardiac compression after cardiac operations in 1975, and suggested external traction as a method of relieving this compression [1]. Jögi and Werner actually confirmed this theory by measuring the detrimental hemodynamic effects of chest closure after complex cardiac operations for congenital disease. They related the intolerance to closure to a fall in the transmural left and right ventricular end-diastolic pressures; in other words, due to impaired filling rather than to a change in contractility [4]. Gielchinsky and associates reported the first series of 29 adult patients with DSC in 1981 [5]. In the same year Gangahar et al. reported relief of tamponade conditions after postoperative sternal reopening in an infant [6].

In 1982, Shore et al. reported a significant decrease in central venous pressure as well as significant increases in blood pressure and urine output after postoperative sternal reopening done because of low output state [7].

DSC after complex operations for congenital heart disease is often necessary in the operating room because of edema, unstable hemodynamic conditions, or bleeding; in addition to all the above it can also be used electively to improve the hemodynamic and respiratory stability in the initial postoperative period [8].

The involvement of sternal closure in the postoperative hemodynamics of pediatric patients was studied by Kay and coworkers using pericardial catheters to measure directly the rise in pericardial pressure after cardiac operations for congenital disease [9]. They found that pericardial pressure climbed significantly after transventricular repair of tetralogy of Fallot or homograft repair of truncus arteriosus. There was a negligible rise in pressure in patients who underwent closed cardiac procedures or transatrial open cardiac operations. More recently, DSC has been described in a few series after pediatric cardiac operations with no or an acceptable additional morbidity compared with PSC, as shown in Table 4 [2,10–20].

Neither in all of the above studies nor in the other main publications concerning this technique were the indications of DSC thoroughly discussed, as they concentrated on the evaluation of the technique without suggesting clear indications or limitations [2,10–20]. We tried to concentrate in this study on the probable indications that we call risk factors for DSC. On the other hand, none of the above studies was focused on the neonatal community of patients. However, we think that neonates are the major subjects of this problem regarding whom this critical decision more frequently arises. It should be also remarked that the feedback of the decision of PSC might be also a determining factor for the postoperative outcome.

For this reason we decided to study this purely neonatal group and to concentrate on the indications for delaying the sternal closure and in other terms the risk factors for DSC. We also decided to study the neonates operated on over a period of 10 years in order to make up a significant number, as our hospital is considered as a small-volume center. We must also

Table 3
Characteristics of patients with DSC a

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>DSC</th>
<th>PDSC</th>
<th>SDSC</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>140</td>
<td>119</td>
<td>21</td>
</tr>
<tr>
<td>Patient age at time of operation (days)</td>
<td>9.6 (&lt;1–27)</td>
<td>8.7 (2–23)</td>
<td>12.3 (4–25)</td>
</tr>
<tr>
<td>Patient weight at time of operation (kg)</td>
<td>3.4 (1.8–4)</td>
<td>3.3 (1.8–3.8)</td>
<td>3.7 (2.9–3.9)</td>
</tr>
<tr>
<td>Cardiopulmonary bypass time (min)</td>
<td>147 (39–238)</td>
<td>151 (49–238)</td>
<td>140 (39–201)</td>
</tr>
<tr>
<td>Aortic clamping time (min)</td>
<td>71 (35–162)</td>
<td>76 (41–162)</td>
<td>60 (35–112)</td>
</tr>
<tr>
<td>Mortality</td>
<td>30 (21.4%)</td>
<td>22 (18.5%)</td>
<td>8 (38%)</td>
</tr>
</tbody>
</table>

 a Data presented are median with range in parentheses (mortality no. and%).

Airway pressures as an indicator for the risk of PSC due to lack of intraoperative recordings.

Table 4
Comparison of all pediatric series of DSC in the literature

<table>
<thead>
<tr>
<th>Series [Ref.]</th>
<th>No. of pediatric patients</th>
<th>% of total</th>
<th>Age range</th>
<th>No. with wound infection (%)</th>
<th>Deaths (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bex (1980)</td>
<td>4</td>
<td>Not reported</td>
<td>10 days–8 years</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Björk (1982)</td>
<td>5</td>
<td>Not reported</td>
<td>Not reported</td>
<td>0 (0)</td>
<td>3 (60)</td>
</tr>
<tr>
<td>Shore (1982)</td>
<td>9</td>
<td>Not reported</td>
<td>6 weeks–6 years</td>
<td>0 (0)</td>
<td>2 (22.2)</td>
</tr>
<tr>
<td>Fanning (1987)</td>
<td>12</td>
<td>Not reported</td>
<td>10 weeks–9 years</td>
<td>1 (8.3)</td>
<td>2 (16.7)</td>
</tr>
<tr>
<td>Odim (1989)</td>
<td>9</td>
<td>30</td>
<td>3–31 days</td>
<td>0 (0)</td>
<td>2 (22.2)</td>
</tr>
<tr>
<td>Baumgart (1991)</td>
<td>9</td>
<td>3</td>
<td>3 months–19 years</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Hakimi (1994)</td>
<td>55</td>
<td>61.8</td>
<td>1–27 days</td>
<td>1 (2.3)</td>
<td>11 (20)</td>
</tr>
<tr>
<td>Tabbutt (1997)</td>
<td>178</td>
<td>100</td>
<td>Not reported</td>
<td>21 (6.7%)</td>
<td>34 (19)</td>
</tr>
<tr>
<td>McElhinney (2000)</td>
<td>128</td>
<td>100</td>
<td>1 day–1 year</td>
<td>1 (0.8%)</td>
<td>14 (11)</td>
</tr>
</tbody>
</table>
remark that this number was somewhat controlled by our tendency in the early 1990s to prefer palliative or two-stage procedures rather than open-heart procedures in neonates with Fallot’s tetralogy and intracardiac malformations associated with the syndrome of neonatal aortic coarctation.

During the time period covered by this retrospective study, several changes have been noted in the operative (and probably even pre- and postoperative) management of the patients. This is on one hand a limitation of the power of the study but, on the other hand, this allowed us to study a lot of different factors. The fact that the overall incidence of DSC did not change over this time period gives a relative value to the actual significance of the statistical results. But it must be kept in mind that it may reflect also that, despite an increasing number of more complex cases and more severe preoperative status, those changes allowed the incidence of DSC to remain stable.

Our study showed that among all the claimed risk factors studied we found that having less than 7 days of age, a diagnosis of either IAA or TAPVD, aortic clamping time exceeding 98 min, cardiopulmonary bypass time longer than 185 min or a central venous saturation postbypass with the chest retractor in place lower than 51%, were statistically significant \((P < 0.05)\) as effective risk factors. To our surprise, many of the factors we previously thought to be undoubtedly risk factors for DSC such as low body weight, prematurity, preoperative assisted ventilation, preoperative inotropic support, prostaglandin infusion, total circulatory arrest with profound hypothermia, and the type and mode of myocardial protection and ultrafiltration had no statistical risk significance. It is also interesting that the pathologies associated with a statistically significant risk to DSC are those associated with increased pulmonary vascular resistance, either due to preoperative pulmonary venous stasis in TAPVD or preoperative plethora in IAA.

During the last 6 months and after the early results of our study, we applied these suggestions on all the operated neonates and none of our patients had SDSC in this period. The mortality in our DSC group (not related to the procedure itself) was acceptable (21.4%; 18.5% in the PDSC group and 38% in the SDSC group) compared with the range of mortality reported for the DSC in the literature (11–36%, keeping in mind that this range was given in heterogeneous groups with an older pediatric population and without including the SDSC population) [9–15]. The mortality rate in the SDSC group (38%) was markedly higher than that in the PDSC group (18.5%), and this gives more value to our trial to predict the need of delaying the sternal closure even in cases of temporary hemodynamic stability and a successful trial of closure. We have to remark also that this mortality was not related to the technique in any of our patients. The causes of mortality in this group was low resistance shock after perioperative peritonitis in one patient (3.3%), disseminated intravascular coagulopathy in four (13.3%), intractable arrhythmia in seven (23.3%) and intractable myocardial dysfunction with multiorgan failure in 18 (60%); among these 18 patients, 12 died due to low cardiac output secondary to severe pulmonary hypertension before the beginning of the nitrous oxide era.

Since the report of Fanning and his associates considering DSC as a life-saving measure in certain patients after open-heart operations [12], the technique has become more popular. At the beginning many closed the skin leaving the sternum opened, but this method was not very satisfactory because the sternum with not retracted enough to give the heart the needed space. In 1990 Majid came up with the idea of the plastic struts to keep the sternal edges retracted to the required distance [21]. The skin gap is closed using a transparent synthetic airtight patch that protects against infection and at the same time allows one to see accumulating effusion or clots that can be easily evacuated. During the last 18 months we have started to fix the skin patch to the superficial part of the subcutaneous tissue, thus avoiding skin necrosis that results in an ugly scar after DSC.

5. Conclusion

The technique of delayed sternal closure is a simple, safe and very useful technique that helps to overcome the problem of pseudo-tamponade after open-heart procedures in neonates. Many of the supposed risk factors associated with the need for delayed sternal closure such as the body weight, prematurity, preoperative inotropic support, preoperative assisted ventilation, profound hypothermia, circulatory arrest, type of cardioplegia and the use of ultrafiltration were not statistically significant as risk factors. On the other hand the age of less than 7 days, increased pulmonary vascular resistance as in TAPVD and IAA, aortic clamping time longer than 98 min, cardiopulmonary bypass time longer than 185 min and a central venous saturation in postbypass less than 51% were statistically significant risk factors for DSC. The mortality in the SDSC group is significantly higher than that of the PDSC group (38 versus 18.5%). All of the patients who had a clamping time exceeding 104 min, a bypass time exceeding 196 min and/or a central venous saturation less than 47% in postbypass and had PSC were reopened in emergency in the first postoperative 48 h. In short, we think that prediction of the need of PDSC is possible (bearing in mind these risk factors even in cases of temporary apparent hemodynamic stability) and is important in order to avoid the higher mortality associated with SDSC. We also think that with more studies on larger groups from several centers it might be possible to set up a risk score for PDSC that would be a valuable decision-making guide.

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References


