ESCVS article - Cardiac general

How good patient blood management leads to excellent outcomes in Jehovah’s witness patients undergoing cardiac surgery

Maximilian Y. Emmert, Sacha P. Salzberg, Oliver M. Theusinger, Christian Felix, Simon P. Hoerstrup, Volkmar Falk, Juerg Gruenenfelder

Keywords: Jehovah’s witnesses; Cardiac surgery; Off-pump surgery; Patient blood management

Abstract

Objectives: The refusal of blood products makes open-heart surgery in Jehovah’s witnesses (JW) an ethical challenge. We demonstrate how patient blood management strategies lead to excellent surgical outcomes. Methods: From 2003 to 2008, 16 JW underwent cardiac surgery at our institution. Only senior surgeons performed coronary revascularization (n=6), valve (n=6), combined (n=1) and aortic surgery (n=3) of which two patients presented with acute type-A dissection. Off-pump surgery remained the method of choice for patients requiring a bypass procedure (n=5). Preoperative hematocrit (Hk) and hemoglobin (Hb) were 42.8±4.7% and 14.5±2 g/dl. In three patients with an Hb<12 g/dl, preoperative hematological stimulating treatment was implemented. Results: All patients survived, no major complications occurred and no blood transfusion was administered. The Cell Saver® system (transfused volume: 474±101 ml) and synthetic plasma substitutes [Ringer’s Lactate: 873±367 ml and hydroxyethyl starch (HES) 6%: 700±388 ml] were used routinely as well as hemostatics, such as bone wax, and fibrin glue. The decrease of Hk and Hb appeared to be the lowest after off-pump surgery when compared to all other procedures requiring cardiopulmonary bypass (CPB) (25±9% vs. 33±6%; P=0.01 and 22±9% vs. 31±6%; P=0.04). Similarly, the decrease of platelets was significantly lower (20±12% vs. 43±14%; P=0.01). In the follow-up period (52±34 months), one patient died due to a non-cardiac reason, whereas all others were alive, in good clinical condition and did not have major adverse cardiac events (MACE) or recurrent symptoms requiring re-intervention. Conclusion: Patient blood management leads to excellent short- and long-term outcomes in JW. Combined efforts in regard to preoperative hematological parameter optimization, effective volume management and meticulous surgical techniques make this possible but raise the cautionary note why this is only possible in JW patients.

Keywords: Jehovah’s witnesses; Cardiac surgery; Off-pump surgery; Patient blood management

1. Introduction

Jehovah’s witnesses (JW) belong to a religious group refusing any type of blood transfusion when requiring surgery [1]. This denial includes whole blood units as well as its four major components: red and white blood cells, platelets and plasma [2]. For this reason, the surgical treatment remains a challenge in this subset of patients, and particularly when they are undergoing cardiac procedures which are well known to be associated with an increased blood-loss.

The invasive nature of a cardiac procedure, the associated decrease of body temperature and especially the use of cardio-pulmonary bypass (CPB) are major reasons for an increased blood loss and the high incidence for blood transfusions during and after cardiac surgery. Beside its associated complications, such as stroke, renal dysfunction, and systemic inflammatory response syndrome (SIRS), especially CPB is well-established to be linked with an increased postoperative bleeding [3]. These patients are good surgical candidates, but are high-risk, as highlighted by previous reports demonstrating safety and feasibility in the setting of cardiac surgery [4–8].

Allogenic blood transfusions are often necessary in cardiac surgery, they do however increase mortality, morbidity and major adverse outcomes [9]. Reduction in the use of blood products should be a general desire for every patient due to the associated risk factors. Next, the costs of red blood cell (RBC) transfusions have been underestimated, even when excluding the cost of treatment of these adverse outcomes or prolonged intensive care and hospital stay related to RBC transfusions [10]. However, most surgeons are neither aware of those problems nor of the fact that patient blood management comprises three main elements: 1) correction of perioperative anemia, 2) minimizing perioperative blood-loss and 3) using low hemoglobin-based transfusion triggers. This principle which is applied in JW should be implemented for all patients undergoing cardiac surgery.
The evolution of less invasive cardiac approaches, such as off-pump procedures for myocardial revascularization or minimally-invasive valve repair [11] may contribute to a further reduction of blood transfusion. Furthermore, off-pump surgery even allows coronary artery bypass grafting (CABG) while avoiding CPB. Various data are available reporting decrease of postoperative complications and blood transfusions in patients undergoing the off-pump approach [12, 13] and although these minimally invasive techniques may benefit every patient, they might be particularly valuable for JW.

Feasibility of bloodless cardiac surgery was recently highlighted by Helm and colleagues who successfully demonstrated avoidance of any blood transfusion in 100 consecutive patients who underwent CABG procedures [14].

In this report, we present our experience in JW undergoing complex cardiac procedures, and the way to use patient blood management for improved surgical outcome in such patients.

2. Materials and methods

2.1. Demographics

A single center retrospective database analysis was conducted. From 2003 to 2008, 16 JW patients underwent cardiac surgery at our institution after informed consent was obtained. All surgical procedures were performed by senior staff surgeons and indication for surgery was mostly elective (87%; n = 14). Six patients required coronary revascularization (n = 6), six patients had valve surgery (n = 6), of which one patient had a double-valve and one patient a triple-valve procedure. One patient underwent a combined procedure and three patients received aortic surgery including two emergent cases with an acute type-A dissection. Off-pump coronary surgery remained the method of choice for patients requiring a bypass procedure (n = 5). A database review (Dendrite) was performed and an additional thorough medical chart review was done when necessary to collect preoperative, intra-operative, and postoperative variables. The protocol was approved by our local institutional review board, including a waiver of informed consent. Table 1 resumes patient’s demographics, including EuroSCORE, co-morbidities, type of medication as well as preoperative data.

2.2. Preoperative informed consent and documentation

In cases of elective surgery, the responsible surgeon and at least two anesthetists discussed the surgical procedure together with the patient. It was determined and documented in detail if and to which extend the patient refuses blood transfusion [including erythrocyte concentrates, fresh-frozen plasma (FFP) and platelets] and what are the alternative options in case of extended intra-operative blood loss. Various approaches, such as aggressive preoperative hemoglobin optimization (iron/folic acid preparations and/or erythropoietin therapy), intra-operative application of hemostatic agents and administration of an autologous re-transfusion (Cell Saver® system) were discussed with the patient.

### Table 1. Preoperative demographics

<table>
<thead>
<tr>
<th>Parameters</th>
<th>n = 16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>63 ± 17</td>
</tr>
<tr>
<td>Male</td>
<td>11 (69)</td>
</tr>
<tr>
<td>Female</td>
<td>5 (31 )</td>
</tr>
<tr>
<td>EuroSCORE</td>
<td>5.7 ± 1.9</td>
</tr>
<tr>
<td>EF (%)</td>
<td>65 ± 7</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>28 ± 6</td>
</tr>
<tr>
<td>History of smoking (%)</td>
<td>9 (56 )</td>
</tr>
<tr>
<td>Diabetes (%)</td>
<td>7 (44 )</td>
</tr>
<tr>
<td>Hypertension (%)</td>
<td>8 (50 )</td>
</tr>
<tr>
<td>PAD (%)</td>
<td>4 (25 )</td>
</tr>
<tr>
<td>COPD (%)</td>
<td>3 (19 )</td>
</tr>
<tr>
<td>Positive family history (%)</td>
<td>6 (37 )</td>
</tr>
<tr>
<td>Elective surgery (%)</td>
<td>14 (62)</td>
</tr>
<tr>
<td>Emergent surgery (%)</td>
<td>2 (10 )</td>
</tr>
<tr>
<td>Redo surgery (%)</td>
<td>0 (0 )</td>
</tr>
<tr>
<td>ACE inhibitors (%)</td>
<td>6 (37 )</td>
</tr>
<tr>
<td>β-Blocker (%)</td>
<td>8 (50 )</td>
</tr>
<tr>
<td>Aspirin (%)</td>
<td>15 (94)</td>
</tr>
<tr>
<td>CABG on-pump/off-pump</td>
<td>1/5</td>
</tr>
<tr>
<td>Valve surgery</td>
<td>6</td>
</tr>
<tr>
<td>Combined procedures</td>
<td>1</td>
</tr>
<tr>
<td>Aortic surgery</td>
<td>3</td>
</tr>
<tr>
<td>Hemoglobin (g/dl) preoperative</td>
<td>14.5 ± 2.0</td>
</tr>
<tr>
<td>Hematocrit (%) preoperative</td>
<td>42.8 ± 4.7</td>
</tr>
<tr>
<td>Red blood cell count (10/µl) preoperative</td>
<td>4.8 ± 0.6</td>
</tr>
<tr>
<td>Platelets (10/µl) preoperative</td>
<td>235 ± 55</td>
</tr>
<tr>
<td>Quick (%) preoperative</td>
<td>109 ± 9</td>
</tr>
<tr>
<td>INR preoperative</td>
<td>0.97 ± 0.1</td>
</tr>
<tr>
<td>Fibrinogen (g/l) preoperative</td>
<td>3.4 ± 1.1</td>
</tr>
</tbody>
</table>

EF, ejection fraction; BMI, body mass index; CABG, coronary artery bypass grafting; INR, international ratio; ACE, angiotensin converting enzyme.

2.3. Preoperative treatment regimen

As iron deficiency anemia is the most common form of anemia, with an incidence of 5–75% [15] of perioperative patients, intra venous iron supplementation, and erythropoietin were recommended to raise hemoglobin level, as per current standard of care [16, 17]. The treatment consisted of 300 IU/kg BW of erythropoietin, 0.5–1.0 g of i.v. iron (Ferinject, ferric carboxymaltose, Vifor SA, Villars sur Glâne, Switzerland) as well as vitamin B12 and folic acid once a week for a period of three weeks.

In patients without iron deficiency and preoperative hemoglobin values between 10 and 13 g/dl a treatment with 600 IU/kg BW of erythropoietin was started three weeks prior to surgery with 0.2–0.5 g of i.v. iron (Ferinject, ferric carboxymaltose, Vifor SA, Villars sur Glâne, Switzerland) as well as vitamin B12 and folic acid once a week for a period of three weeks.

If patients had a known personal or familial history of thromboembolic events, if they had a severe hypertension or were allergic to the agent or other ingredients, EPO was not administered, and treatment was stopped once a hemoglobin of >15 g/dl was achieved.

2.4. Surgical techniques

All operations were performed through a median sternotomy. Standard techniques of CPB were initiated, the aorta was cross clamped and cold-blood cardioplegia was admin-
istered antegrade and retrograde. Heparin was reversed following weaning from the CPB. In the setting of off-pump coronary artery revascularization, heparin was administered to obtain active clotting time in excess of 300 seconds at the completion of the procedure heparin was antagonized with protamine.

2.5. Intra-operative management

In all patients hemodynamic optimization was attempted by fluid resuscitation [such as Ringer’s Lactate and hydroxyethyl starch (HES)], trendelenburg positioning and catecholamine administration. Transesophageal echocardiography (TEE) and pulmonary artery catheter (Edwards Lifesciences, Irvine, CA, USA) measurements were used to assess hemodynamic compromise. Body temperature was continuously monitored and adapted to the surgical procedure to prevent additional blood loss, hypothermia <35 °C was avoided to reduce blood loss due to coagulopathy, and warming systems like Bair Hugger™ (Arizant Inc, Eden Prairie, MN, USA) and Buddy™ (Belmont Instrument Corp., Billerica, MA, USA) were used. In addition to this, the Cell Saver™ system (Haemonetics Corp, Braintree, MA, USA), an indirect re-transfusion system was applied for continuous autotransfusion for efficient blood salvage in patients who accepted this system. The continuous connection was guaranteed by a line from the Cell Saver™ washed blood bag to maintain an intact circuit to the patient. No blood was cross-matched before, during, or after the operation; no blood derivatives, such as plasma, albumin, or cryoprecipitate, were administered to the JW. The only fluid received by the JW patients was priming solution, Ringer’s Lactate and HES. Controlled hypotension (mean arterial pressure 50–55 mmHg) was also used to reduce intraoperative blood loss.

To minimize bleeding of the sternum bone wax (Bonewax; Johnson and Johnson, Beerse, Belgium) was used as standard in every patient. Other synthetic hemostatic agents, such as fibrin glue Tissucol™ Duo S (Tissucol, Baxter, Deerfield, IL, USA), Tabotamp Nu-Knit™ (Ethicon, Johnson & Johnson, Somerville, NJ, USA), Arista™ (microporous polysaccharide hemospheres; Medafor, Inc, Minneapolis, MN, USA), Coseal™ (Baxter Healthcare International, Palo Alto, CA, USA) and Vivostat™ (Vivolution A/S, Birkerod, Denmark) were administered to stop and minimize blood loss from diffuse bleeding.

2.6. Postoperative management and blood loss control

The postoperative management in the intensive care unit (ICU) consisted in maintaining a good perfusion of organs and tissues and applying patient blood management. Mean arterial pressure had to be between 60 and 70 mmHg, and when needed noradrenaline, phenylephrine, dobutamine and vasopressin were used. Fluid therapy was unfortunately not consistent and depended on the anesthesiologist as well as his conviction on liberal vs. restrictive fluid therapy. Since fluid overload and positive fluid balance are linked to poor outcome, infusion therapy should be rational and aim to prevent edema as well as to preserve of micro-vascular blood flow and adequate tissue oxygenation. The same problem has to be mentioned for fast-track surgery, as not all patients have been rapidly extubated where it would have been possible. Laboratory controls and blood drawn was reduced to a minimum. Coagulation was controlled by laboratory values as well as by ROTEM® (Rotation thromboelastometry, TEM® International, Munich, Germany) and JW who prior to surgery accepted substitution of fibrinogen and coagulation factors (e.g. factor XIII, PBSB) were substituted according to institutional guidelines. The algorithm for transfusion was previously published by Theusinger et al. [18] and made goal-directed transfusions possible and allowed the reduction of the use of blood products in general as well as a reduction in costs, which is an advantage for all patients and not only for JW.

2.7. Statistical analysis

Continuous variables are shown as mean and standard deviation. Categorical or dichotomous data are presented in frequencies and percentage (%). All the statistical analyses were performed using GraphPad Prism® software version 5.01 for Windows (GraphPad Software, San Diego, CA, USA). Continuous variables were analyzed using a Mann–Whitney U-test. Statistical significance was assumed at \( P \leq 0.05 \).

3. Results

3.1. Demographics and preoperative parameters (Table 1)

In our series, male gender was predominant (64%), mean age was 63±17 years and preoperative EuroSCORE was 5.7±1.9. The mean preoperative ejection fraction (EF) was 65±7%, mean body mass index (BMI) was 28±6 and the patients presented with a classical cardiovascular risk profile. Preoperative hemoglobin (Hb), hematocrit (Hk) and platelets were 14.5±2.0 g/dl, 42.8±4.7 g/dl, 255±103±10/μL. Three patients required preoperative i.v. iron and erythropoietin therapy due to low hemoglobin levels (≤12 g/dl). Quick (103±9%) and international ratio (INR) (0.97±0.07) were normal in all patients.

3.2. Intra-operative parameters (Table 2)

No blood transfusions occurred, while hemodynamic substitution was performed with Ringer’s Lactate (873±367 ml), Voluven (700±388 ml) and indirect re-transfusion via the Cell Saver™ (474±101 ml). In addition to this, trendelenburg positioning, atrial pacing and/or catecholamines were applied in the OPCAB setting. The mean duration of the procedure was 246±39 minutes, mean CPB-time was 75±60 minutes, mean cross-clamp time was 49±40 minutes and among patients who underwent the off-pump approach, no emergent conversion to CPB was necessary. To further minimize bleeding, particularly after sternotomy, at the stitching channels, after cannula removal and in terms of diffuse bleeding, standardized synthetic hemostatics were administered as follows: bone wax (100%) fibrin glue Tissucol™ Duo S (25%), Tabotamp Nu-Knit™ (31%), Arista™ (31%), Coseal™ (19%) and Vivostat™ (6%).
3.3. Mortality, early postoperative course and long-term follow-up (Table 3)

All patients survived the operation and neither intraoperative nor postoperative blood transfusion became necessary. Except for one episode of ventricular fibrillation in one patient which could be immediately terminated via defibrillation, no complications occurred postoperatively. No re-exploration for bleeding was necessary and all patients had a swift postoperative course. Mean postoperative ventilation time was 548 ± 235 minutes, and except for two patients, all others were transferred from the ICU on the first postoperative day (mean length of ICU stay 25.9 ± 12.2 hours).

The mean Hb and Hk at the third postoperative day was 10.0 ± 1.5 g/dl and 29.5 ± 4.5% and the mean decrease in comparison to the preoperative levels was 31 ± 8% and 31 ± 7%. After a mean hospital stay of 7 ± 1 days, the patients were discharged with a mean Hb of 10.6 ± 1.2 g/dl and Hk of 32.2 ± 3.2%.

In addition to this, it became apparent that the early postoperative decrease of Hb and Hk serum levels was lowest in patients who underwent an off-pump approach for myocardial revascularization when compared to all other procedures requiring CPB (25 ± 9% vs. 33 ± 6%; P = 0.01 and 22 ± 9% vs. 31 ± 6%; P = 0.04). Similarly, the decrease of platelets was significantly lower (20 ± 12% vs. 43 ± 14%; P = 0.01) and did not drop below the normal range of 150–400 10^12/μl even after off-pump surgery (Table 4).

The mean follow-up time was 52 ± 34 months and was completed in all patients (100%, n = 16). Within this period, one patient died due to a non-cardiac reason (pneumonia). All other patients were alive, were in good health and had returned to normal life. None of them reported having any major adverse cardiac events (MACE) or any recurrent cardiac symptoms requiring redo surgery or a re-intervention.

4. Discussion

Our results demonstrate safety and feasibility of complex open-heart surgery in JW and highlight that patient blood management leads to excellent clinical outcomes in the short- and long-term. Combined efforts in regard to preoperative hemoglobin optimization, effective intraoperative volume management as well was goal directed transfusion strategies, senior surgical staff and modern surgical techniques make this possible and permit complete avoidance of blood transfusion.

Although only few studies are available [4–8] our findings are supported by a recent report of Stamou and colleagues who systematically compared the operative mortality and early clinical outcome after open cardiac surgery in JW vs. non-JW. The authors found cardiac surgery in JW to be associated with clinical outcomes comparable to those of non-JW by adhering to blood conservation protocols [4]. Juraszek et al. reviewed 35 JW of which, 18 patients underwent CABG (13 × on-pump CABG/5 × off-pump CABG). They found a mean preoperative hematocrit level of 35.8 ± 6.3% with a mean decrease of 20.0 ± 21.1% after surgery. The mean decrease of hematocrit levels in patients undergoing CABG without CPB was 12.5 ± 5.4% and 12.0 ± 20.0% in patients after isolated valve replacement. One patient died during the operation and four patients died in the postoperative period due to anemia. The authors concluded that the decrease of hematocrit serum levels significantly characterizes the postoperative period of open-heart surgery in JW. Next they suggested off-pump CABG as the method of choice in JW requiring isolated myocardial revascularization as the decrease of hematocrit serum levels was the lowest [5].

These data clearly indicate safety and feasibility of patient blood management in cardiac surgery in JW. In addition to this, we and others [5] believe that minimally-invasive techniques, such as OPCAB may be the method of choice for JW requiring isolated myocardial revascularization. Various reports have clearly demonstrated that a modern OPCAB approach is associated with a decreased
blood loss requiring lesser blood transfusions [3]. One major reason might be the avoidance of CPB which is well-known to have a higher risk for intra-operative and postoperative bleeding [3]. This is also confirmed by our results showing that the decrease of hemoglobin and hematocrit after the OPCAB procedure was lowest and even platelets did not drop under the normal range.

In contrast to this, cardiac valve surgery, even if performed in a minimally-invasive fashion still requires CPB which is known to be a risk for bleeding. To solve this problem, recently developed interventional techniques for aortic valve replacement including trans-apical [19] or trans-femoral approaches [20] permitting valve replacement without CPB may have an important impact and need to be evaluated as a potential treatment option for JW. Similarly, in terms of severe mitral insufficiency requiring mitral valve repair/replacement, the catheter-based mitral clip technique [21] may also be a therapeutic strategy for JW, particularly if they are in advanced age and have a high-risk of open surgery.

Another finding of our study is that the administration of synthetic hemostatics may efficiently contribute to a reduced bleeding from the sternum, the stitching channels and the cannulation areas which are often a potential reason for re-exploration puts the patient at additional risk for blood transfusions. Various reports are available and have demonstrated that hemostatics effectively reduce blood-loss during invasive surgical procedures. Beside the well-established efficacy of bone wax and fibrin glue Tissucol™ Duo S and also newer agents, such as Tabotamp Nu-Knit™, Arista™, Coseal™ and Vivostat™ have proven to be helpful tools for blood loss reduction.

Furthermore, the preoperative correction of anemia is one of the most important steps of patient blood management and also allows JW to undergo major cardiac surgery and to have a certain amount of blood loss [22]. Using the intra-operative Cell Saver® (Haemonetics Corp., Braintree, MA, USA), if accepted by the patient guarantees a continuous connection by a line from the Cell Saver® washed blood bag that has been primed and connected to the patient’s i.v. line to maintain an intact circuit to the patient and allows a reduction in the effective loss of RBCs [23]. Volume management is the major aspect for the intra- and postoperative management, since fluid overload is linked to poor outcome [24] and is also linked to coagulopathy [25] and as such is a not too ‘liberal’ approach should be used. Intra- and postoperative bleeding management can easily be performed by ROTEM® (TEM® International, Munich, Germany) and allows for correcting coagulation factors if previously accepted by patients, such as fibrinogen, factor XIII and PBSB.

In these cases, patient blood management allowed major cardiac surgery without using any blood. The question which has to be raised is why patient blood management is not available for all patients since it is known that outcome and survival are much better without using blood.

Non-JW patients still bleed more and still get too many blood products. We believe that possible reasons are that surgeons are younger and have less experience leading to longer operating times, whereas JW patients were only operated by experienced senior surgeons. Furthermore, non-JWs suffer from hypothermia below 35 °C which leads to a coagulopathy leading to an increased blood loss. Next, perioperative anemia is not detected and not treated. Moreover, the anesthesiological management regarding volume management, transfusion triggers and the recognition of coagulation disorders is not standardized. These problems have to be solved rapidly because all patients should benefit from this patient blood management program not only JWs, where it has been proven to be efficient.

Feasibility of bloodless cardiac surgery has been recently elucidated by Helm and colleagues. One hundred consecutive patients undergoing CABG were prospectively enrolled in a risk-factor based multimodality blood conservation program (MMD) and compared to a similar group of 90 patients undergoing CABG to whom the MMD was not applied. The 100 consecutive patients in the MMD group successfully underwent CABG without blood transfusion whereas 38% patients in the control population received allogeneic blood. Moreover, the volume of postoperative blood loss at 12 hours in the control group was almost double that of the MMD group. The authors came to the conclusion, that a comprehensive risk-factor based application of multiple blood conservation measures can significantly decrease bleeding and the need for allogeneic transfusion in CABG in a safe and cost-effective manner [14].

In conclusion, patient blood management leads to excellent outcomes in JW patients and should be the standard care for every patient. Combined efforts in regard to preoperative hematological parameter optimization, effective intra-operative volume management, senior surgical staff and modern surgical techniques make this possible but raise the cautionary note why this is only possible in JW patients.

5. Limitations

Of course, this is a retrospective analysis and all disadvantages apply. Next, we certainly would have achieved a higher degree of significance had we analyzed a larger cohort of patients. However, this is not a specific problem of this study, as the number of analyzed patients available

---

**Table 4. Mean decrease of hematological parameters after off-pump procedures vs. on-pump procedures**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Off-pump preoperative/early postoperative</th>
<th>On-pump preoperative/early postoperative</th>
<th>Mean decrease off-pump vs. on-pump</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemoglobin (g/dl)</td>
<td>13.2 ± 1.2/9.9 ± 1.2</td>
<td>15.0 ± 1.7/10.1 ± 1.7</td>
<td>25 ± 9% vs. 33 ± 6%</td>
<td>0.01</td>
</tr>
<tr>
<td>Hematocrit (%)</td>
<td>39.1 ± 3.2/30.5 ± 1.2</td>
<td>43.3 ± 5.4/29.8 ± 4.9</td>
<td>22 ± 9% vs. 31 ± 6%</td>
<td>0.04</td>
</tr>
<tr>
<td>Platelets (10^9/μL)</td>
<td>262 ± 53/210 ± 39</td>
<td>222 ± 53/126 ± 37</td>
<td>20 ± 12% vs. 43 ± 14%</td>
<td>0.01</td>
</tr>
</tbody>
</table>
in the literature is also very low. Although our approach was successful in two emergency patients suffering from acute type-A dissection, this multidisciplinary approach is mainly applicable to elective patients.

References