Established markers of renal and hepatic failure are not appropriate to predict mortality in the acute stage before extracorporeal life support implantation†

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Abstract

OBJECTIVES: End-organ function, especially of the kidney and liver, actual inflammation and acid–base balance affect the outcome in extracorporeal life support (ECLS) patients. However, the often unexpected necessity of ECLS implies that information on patients is scarce. Even established global scores are not always useful in the rapid decision process for ECLS. Therefore, we evaluated laboratory parameters for kidney or liver function and for inflammation and acid–base balance with regard to outcome.

METHODS: The retrospective analysis includes 69 consecutive adult patients with veno-arterial ECLS. Laboratory markers for function of kidney (creatinine, urea) and liver (total bilirubin in plasma, glutamate oxaloacetate transaminase and glutamate pyruvate transaminase) as well as for inflammation (C-reactive protein, leucocyte counts) and acid–base balance (pH, lactate) were acquired within 24 h before ECLS implantation.

RESULTS: A total of 38 patients (55%) could be weaned or bridged. Bridged patients were switched to ventricular assist devices, n = 10, or total artificial hearts, n = 2, and one patient underwent heart transplantation. Overall, 26 ECLS patients (38%) survived for >4 weeks. Thirty-one patients (45%) died on ECLS. About three out of four patients presented with impaired renal or hepatic performance, approximately two-thirds with signs of increased inflammatory state, and more than a half with deranged acid–base balance. Neither signs of hepatic or renal failure nor of inflammation or impaired acid–base balance allowed a prediction of survival in these patients. The outcome did also not depend on indication for ECLS implantation. However, there was a significant correlation between the patients’ age and mortality (P = 0.006).

CONCLUSIONS: Our data indicate that renal and hepatic insufficiency, increased inflammatory state and deranged acid–base balance as determined by pre-operative laboratory data are not associated with poor outcome of ECLS. Further, survival is not related to indications for ECLS. In a number of patients, ECLS allows for successful bridging to other treatment options.

Keywords: Extracorporeal life support • End-organ function • Outcome

OBJECTIVE

Extracorporeal life support (ECLS) is an option for patients with presumably temporary cardiac or combined heart and lung failure [1]. The first successful use in an adult was reported in 1972 [2]. Typical indications include post-cardiotomy failure, cardiopulmonary resuscitation, acute myocardial infarction or myocarditis and decompensated chronic heart failure [1]. Another option is ECLS as a bridge to the decision for implantation of a (long-term) ventricular assist device (VAD) [3, 4]. The recent technical development with decreasing size and weight of ECLS systems allows us to institute ECLS in remote hospitals followed by transfer to specialized centres [5].

The outcome of ECLS patients is affected by end-organ function. However, the often unexpected necessity of ECLS implies that information on the patients is scarce and sometimes even basic laboratory values are not available. With regard to kidney injury, classifications such as RIFLE (risk, injury, failure, loss of kidney function, end-stage renal failure) or AKIN (acute kidney injury network) may correctly predict ECLS outcome [6]. However, they are not applicable pre-operatively, since they are based on relative changes in previous values which are not available for most patients. Even global scores that have been shown to anticipate mortality quite reliably in cardiac surgery patients in the intensive care unit (ICU), such as sequential organ failure assessment (SOFA) or cardiac surgery score (CASUS), are not always useful in...
the rapid decision-making for ECLS [7, 8]. Further, markers of liver function and inflammation were shown to predict mortality in heart failure [9, 10]; acid-base balance was frequently used to evaluate patients on the ICU after cardiac surgery [11, 12].

In this study, we compared laboratory data from unselected ECLS patients with regard to their predictive values.

**METHODS**

**Patients**

The retrospective analysis includes 69 consecutive adult patients who received veno-arterial ECLS between March 2007 and August 2011. The study was approved by the Ethics Committee of the Albert Ludwigs University Freiburg. Data were acquired within 24 h before ECLS implantation. All devices were implanted at the Department of Cardiovascular Surgery, Medical Center University Freiburg, Freiburg, Germany or with the assistance of a perfusionist from our department.

Patients with intra-operative post-cardiotomy failure were placed on ECLS when weaning from cardiopulmonary bypass was not successful. The other patients required ECLS due to circulatory failure mainly caused by an underlying cardiac disease. In these cases, leading criteria for ECLS management included the increasing need for inotropic medication and decreasing pH despite maximized intensive care. Once established, management of the ECLS aimed at maintaining stable organ oxygenation and perfusion with a cardiac index of 2.2–2.8 l min⁻¹ m⁻².

**Laboratory parameters**

Assessment included laboratory markers for function of kidney (creatinine, urea) and liver [glutamate oxaloacetate transaminase (GOT), glutamate pyruvate transaminase (GPT) and total bilirubin in plasma (TBIL)] and for inflammation [C-reactive protein (CRP), leucocyte counts] and acid-base balance (pH, lactate). Measurements were done at the Department of Clinical Chemistry of the University Medical Center Freiburg or on ABL800 flex analyzer (Radiometer, Brønshøj, Denmark) according to the standard procedures. Not all parameters were assessed for each patient; therefore, patient numbers in the results vary.

**Statistics**

The program PASW Statistics 18 (SPSS Inc., Chicago, IL, USA) was used for all calculations. The Kruskal–Wallis, Mann–Whitney U and Goodman–Kruskal τ tests were employed for comparison of groups. The level of significance was set at ≤0.05.

**RESULTS**

**Patients and outcome**

Sixty-nine consecutive adult patients with a mean age of 56 ± 15 years (range 21–88, median 56 years) were analysed. Main indications were ischaemic cardiomyopathy, post-cardiotomy failure, cardiac graft failure and dilative cardiomyopathy. Other indications included the dysfunction of an implant (aortic valve, mitral valve or VAD failure), n = 3, congenital heart defect, n = 1, amyloidosis, n = 1, myocarditis, n = 1, lung transplantation, n = 4, and resuscitation due to accidental hypothermia, n = 1. Indications and outcomes are given in Table 1. Thirty-one patients (45%) received the ECLS within 48 h after admission to any department of our hospital, 26 of them (38%) within the first 24 h. Thirty-eight patients could be weaned or bridged. Weaned patients needed mechanical support for 4.3 ± 3.3 days (range 1–12 days). In bridged patients, ECLS was in place for 6.4 ± 9.1 days (0–32 days). They were switched to (long-term) VADs, n = 10, or total artificial hearts, n = 2, one patient underwent heart transplantation. In total, 26 of the 69 ECLS patients, that is 38%, survived for >4 weeks (Table 2). Thirty-one patients died on ECLS after 4.6 ± 4.6 days (0–15 days) due to cardiac failure (n = 16), multi-organ failure (n = 6), septic shock (n = 4), cerebral hypoxia (n = 3) or intracranial bleeding (n = 2).

**Laboratory data**

Laboratory values obtained within 24 h before ECLS implantation are given in Table 3. According to the laboratory data, 42 of 62 analysed patients presented with renal dysfunction before ECLS implantation, that is, either creatinine or urea or both were elevated. With regard to liver function, GOT was above normal in 39 of 62 tested patients, GPT in 30 of 56 and total bilirubin in 26 of 46 subjects. In only 6 of 42 patients, all three parameters were normal. Five more patients had increased TBIL, but normal GOT and GPT. An inflammatory status was seen in the majority of patients: Forty-seven of 66 analysed patients presented with enhanced CRP, leucocyte counts were increased in 38 of 69. Acidosis was observed in 12 of 16 patients, and lactate levels were raised in 24 of 42 patients.

We found no differences for any of the laboratory data between survivors for >4 weeks and non-survivors (Table 3,}

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Ischaemic cardiomyopathy</th>
<th>Post-cardiotomy</th>
<th>Primary heart transplant failure</th>
<th>Other (see text)</th>
<th>Dilative cardiomyopathy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weaned</td>
<td>25 (36%)</td>
<td>4 (6%)</td>
<td>8 (12%)</td>
<td>7 (10%)</td>
<td>6 (9%)</td>
</tr>
<tr>
<td>Bridged</td>
<td>13 (19%)</td>
<td>6 (9%)</td>
<td>0</td>
<td>1 (1%)</td>
<td>2 (3%)</td>
</tr>
<tr>
<td>Died</td>
<td>31 (45%)</td>
<td>13 (19%)</td>
<td>10 (14%)</td>
<td>4 (6%)</td>
<td>3 (4%)</td>
</tr>
</tbody>
</table>

Percentages are only for orientation, differences to 100% occur due to rounding.
The same result was obtained if only weaned and bridged patients were included. No difference was also revealed by stratification for death on support versus weaning or bridging without regard to survival.

Furthermore, there were no differences in the laboratory data between indications. Survival to weaning or bridging (n = 38) or survival for ≥4 weeks (n = 26) did also not depend on reason for ECLS implantation (P = 0.31 and P = 0.11, respectively) (Fig. 1).

The group ‘other indication’ (see above) was excluded from this analysis due to the high heterogeneity.

### Predictive value of renal failure

For criteria and incidence of acute renal injury (ARI) or severe acute renal failure syndrome (SARFS), see Table 4. No patient met the criteria for ARFS. Pre-ECLS values for creatinine and urea were not available for four patients, but none of them underwent dialysis before support. Five patients received renal replacement therapy prior to ECLS institution. Creatinine concentration in serum was 192.0 ± 134.4 μmol l\(^{-1}\) (range 61.9–439.3, median 146.7 μmol l\(^{-1}\)) and urea came to 11.2 ± 3.1 mmol l\(^{-1}\) (range 7.3–15.3, median 10.0 mmol l\(^{-1}\)) in this group. Two of the five patients needed ECLS for cardiac graft failure and one each for post-cardiotomy heart failure, dysfunctional implant or congenital heart defect. Our data indicate that acute kidney failure, that is ARI or SARFS, was not associated with poor outcome (P = 0.58) (Fig. 1). Of the five patients (of 69) with pre-operative dialysis, one patient survived for >4 weeks after bridging to biventricular support and subsequent heart transplantation.

### Table 2: Survival of weaned or bridged ECLS patients (n, % of all 69 patients)

<table>
<thead>
<tr>
<th>Survival</th>
<th>Ischaemic cardiomyopathy</th>
<th>Post-cardio myopathy</th>
<th>Primary heart transplant failure</th>
<th>Other (see text)</th>
<th>Dilative cardiomyopathy</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weaned</td>
<td>4 weeks</td>
<td>0</td>
<td>6 (9%)</td>
<td>6 (9%)</td>
<td>0</td>
<td>18 (26%)</td>
</tr>
<tr>
<td></td>
<td>≤4 weeks</td>
<td>2 (3%)</td>
<td>1 (1%)</td>
<td>1 (1%)</td>
<td>2 (3%)</td>
<td>7 (10%)</td>
</tr>
<tr>
<td>Bridged</td>
<td>4 weeks</td>
<td>0</td>
<td>1 (1%)</td>
<td>1 (1%)</td>
<td>2 (3%)</td>
<td>8 (11%)</td>
</tr>
<tr>
<td></td>
<td>≤4 weeks</td>
<td>2 (3%)</td>
<td>0</td>
<td>1 (1%)</td>
<td>2 (3%)</td>
<td>5 (7%)</td>
</tr>
</tbody>
</table>

Std: standard deviation; min.: minimum; max.: maximum.

### Table 3: Laboratory values within 24 h before ECLS implantation and P-values for survivors (≥4 weeks) versus non-survivors

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal up to</th>
<th>Unit</th>
<th>Survival</th>
<th>n (%)</th>
<th>Mean</th>
<th>Std</th>
<th>95% confidence interval</th>
<th>Median</th>
<th>Min.</th>
<th>Max.</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower limit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>Years</td>
<td>&gt;4 weeks</td>
<td>26 (100)</td>
<td>49.4</td>
<td>14.4</td>
<td>43.6</td>
<td>55.2</td>
<td>51.5</td>
<td>21.0</td>
<td>74.0</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤4 weeks</td>
<td>43 (100)</td>
<td>60.2</td>
<td>14.0</td>
<td>55.9</td>
<td>64.5</td>
<td>59.0</td>
<td>29.0</td>
<td>88.0</td>
<td></td>
</tr>
<tr>
<td>Creatinine</td>
<td>μmol l(^{-1})</td>
<td>&gt;4 weeks</td>
<td>25 (96)</td>
<td>126.7</td>
<td>53.9</td>
<td>104.5</td>
<td>148.9</td>
<td>120.0</td>
<td>33.6</td>
<td>229.1</td>
<td>0.93</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤4 weeks</td>
<td>40 (93)</td>
<td>132.3</td>
<td>66.8</td>
<td>111.0</td>
<td>153.7</td>
<td>127.7</td>
<td>52.7</td>
<td>451.8</td>
<td></td>
</tr>
<tr>
<td>Urea</td>
<td>mmol l(^{-1})</td>
<td>&gt;4 weeks</td>
<td>23 (88)</td>
<td>10.7</td>
<td>6.1</td>
<td>8.0</td>
<td>13.3</td>
<td>9.2</td>
<td>4.2</td>
<td>33.1</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤4 weeks</td>
<td>39 (91)</td>
<td>12.1</td>
<td>6.2</td>
<td>10.1</td>
<td>14.1</td>
<td>10.0</td>
<td>3.5</td>
<td>30.6</td>
<td></td>
</tr>
<tr>
<td>GOT</td>
<td>μmol s(^{-1})l(^{-1})</td>
<td>&gt;4 weeks</td>
<td>24 (92)</td>
<td>8.1</td>
<td>19.0</td>
<td>0.0</td>
<td>16.1</td>
<td>2.4</td>
<td>0.3</td>
<td>94.2</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤4 weeks</td>
<td>37 (86)</td>
<td>11.9</td>
<td>25.4</td>
<td>3.5</td>
<td>20.4</td>
<td>1.6</td>
<td>0.3</td>
<td>110.5</td>
<td></td>
</tr>
<tr>
<td>GPT</td>
<td>μmol s(^{-1})l(^{-1})</td>
<td>&gt;4 weeks</td>
<td>23 (88)</td>
<td>3.4</td>
<td>6.3</td>
<td>0.7</td>
<td>6.1</td>
<td>0.6</td>
<td>0.2</td>
<td>28.5</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤4 weeks</td>
<td>33 (77)</td>
<td>8.7</td>
<td>19.0</td>
<td>1.9</td>
<td>15.4</td>
<td>1.0</td>
<td>0.1</td>
<td>66.7</td>
<td></td>
</tr>
<tr>
<td>Bilirubin</td>
<td>μmol l(^{-1})</td>
<td>&gt;4 weeks</td>
<td>17 (65)</td>
<td>31.8</td>
<td>20.5</td>
<td>21.3</td>
<td>42.3</td>
<td>32.5</td>
<td>3.4</td>
<td>83.8</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤4 weeks</td>
<td>29 (67)</td>
<td>36.0</td>
<td>35.1</td>
<td>22.6</td>
<td>49.3</td>
<td>23.9</td>
<td>6.8</td>
<td>140.2</td>
<td></td>
</tr>
<tr>
<td>CRP</td>
<td>mg l(^{-1})</td>
<td>&gt;4 weeks</td>
<td>25 (96)</td>
<td>42.4</td>
<td>54.4</td>
<td>20.0</td>
<td>64.9</td>
<td>25.0</td>
<td>1.0</td>
<td>224.0</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤4 weeks</td>
<td>41 (95)</td>
<td>68.0</td>
<td>84.8</td>
<td>41.2</td>
<td>94.8</td>
<td>34.0</td>
<td>1.0</td>
<td>381.0</td>
<td></td>
</tr>
<tr>
<td>Leucocytes</td>
<td>1000 µl(^{-1})</td>
<td>&gt;4 weeks</td>
<td>26 (100)</td>
<td>12.4</td>
<td>5.9</td>
<td>10.0</td>
<td>14.8</td>
<td>11.0</td>
<td>4.8</td>
<td>29.2</td>
<td>0.92</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤4 weeks</td>
<td>44 (100)</td>
<td>13.1</td>
<td>7.7</td>
<td>10.7</td>
<td>15.5</td>
<td>10.3</td>
<td>4.1</td>
<td>38.3</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>≥7.35–7.45</td>
<td>&gt;4 weeks</td>
<td>8 (31)</td>
<td>7.34</td>
<td>0.11</td>
<td>7.24</td>
<td>7.43</td>
<td>7.36</td>
<td>7.46</td>
<td>1.00</td>
</tr>
<tr>
<td>Lactat</td>
<td>mmol l(^{-1})</td>
<td>&gt;4 weeks</td>
<td>15 (58)</td>
<td>6.7</td>
<td>5.0</td>
<td>3.9</td>
<td>9.4</td>
<td>7.0</td>
<td>0.9</td>
<td>15.0</td>
<td>0.51</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤4 weeks</td>
<td>26 (60)</td>
<td>5.8</td>
<td>6.1</td>
<td>3.3</td>
<td>8.2</td>
<td>2.7</td>
<td>0.7</td>
<td>18.0</td>
<td></td>
</tr>
</tbody>
</table>

The only observed risk factor for death on ECLS was age (P = 0.007) (Fig. 1). Also, weaned or bridged patients who survived for >4 weeks were younger (P = 0.006) than those who died. Weaned and bridged patients did not differ.

### DISCUSSION

We evaluated laboratory parameters for kidney or liver function, inflammation and acid–base balance within 24 h before the
A total of 55% of patients were weaned or bridged from the ECLS and 38% survived for >4 weeks. Forty-five per cents died on support. Neither signs of hepatic or renal failure nor of inflammation or impaired acid-base balance allowed a prediction
of survival in these patients. The outcome did also not depend on indication for ECLS implantation. However, there was a significant correlation between the patients’ age and mortality.

### Decision-making and value of scores

Decision-making for starting an ECLS is a difficult task. Although there is vast literature on this short-term mechanical cardiopulmonary support, there is only little information on data that predict the outcome strong enough to be used for ruling. Severe ischaemic brain damage and undue low chances for successful recovery are considered contraindications. Beyond that, even the most up-to-date guidelines do not provide clear recommendations for patients with beginning or definite end-organ failure [1, 5]. A number of scores have been published which estimate the prognosis of patients after cardiac surgery and/or on the ICU [7, 8, 13, 14]. However, they are not validated for the prediction of outcome of patients on the verge of ECLS and can overestimate mortality [15].

In our view, ECLS offers the opportunity of a ‘bridge-to-decision’ situation with two major pathways: (i) primary recovery of circulatory function followed by explantation of the system within a 7-day period and (ii) switch to a permanent VAD if recovery is slow or absent within the first 7 days. Important clinical conditions that expedite institution of ECLS at our department are the rising need for catecholamines and a low pH despite appropriate buffering. However, these are also only relative data, and, in summary, the decision to start ECLS relies on the overall clinical impression of the patient, his or her prognosis, and on the discretion of an experienced team of cardiovascular specialists. To decide on the further proceeding for the patient on ECLS, the focus is set not only on circulatory recovery but also on end-organ function. Conditions of evolving organ failure, especially signs of permanent cerebral dysfunction, are closely monitored and included to a greater extent in decision-making. All observations together finally provide a setting of clinical data which indicate either a limited or a progressive, subsequently generalized, organ failure. The limited organ failure is compatible with continuation of therapy while progressive multi-organ failure signifies the limitation of therapeutic measures.

### Outcome

In recent publications, weaning and/or hospital discharge rates ranged from about one-third after graft failure [16, 17] to about two-thirds after post-cardiotomy shock [11, 18], which is in line with our results. However, these publications consider only selected groups of patients with ECLS support. We included, in contrast, patients with a variety of diseases and indications in terms of a consecutive row of ‘all comers’. Furthermore, our observation that age represents a negative predictor for survival has previously been made by others [11].

In several cases, ECLS was employed to decide whether a patient was eligible for VAD. Selection criteria include a general suitability for VAD support without contraindications for heart transplantation or destination therapy with no advanced organ failure, no severe coagulopathy, no sepsis and no major psychic disorders. Most of these facts are not known in emergency situations and ECLS enables one to observe the development of the patient. Eight of the 13 bridged patients survived.

### Renal failure

Rastan et al. [11] analysed more than 500 ECLS patients. Of all examined medical factors, only recent acute myocardial infarction and renal insufficiency were associated with poor outcome.

The schemes RIFLE and AKIN are frequently used to estimate progress of renal dysfunction [6, 19–21]. As already mentioned, they are not suitable for the prediction of outcome before institution of ECLS, because they depend on comparison with preceding data on renal function. This information is usually not available in an emergency situation. Further, these scores are not always reliable for patients undergoing cardiac surgery [19].

To overcome the disadvantage of needing previous data, Bellomo et al. developed a classification based on absolute values. They defined ARI, acute renal failure syndrome (ARFS) and severe ARFS [22] (compare Table 4 for criteria).

Stage of severity has been shown to correlate with the outcome in ICU patient for all three classification systems [21]. In our ECLS study, even severe ARFS was not significantly associated with death on ECLS, but this observation relies on only very few patients. However, it seems possible that sufficient renal replacement could raise chances for survival by improving the general health status of the patients.

### Liver dysfunction

Hepatic failure and cardiac insufficiency are interdependent. Abnormal liver function is associated with higher mortality in patients with chronic heart failure [9]. Chronic, and also acute, heart failure may cause ischaemic or congestive liver damage, and long-term hepatic cirrhosis induces myocardial and electro-physical dysfunction [23]. In acute situations, extrahepatic

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**Table 4: Laboratory criteria for acute kidney dysfunction** [22] and number of patients

<table>
<thead>
<tr>
<th>Criterion (n = 48)</th>
<th>Limit for normal</th>
<th>n (%)</th>
<th>Limit for ARI</th>
<th>n (%)</th>
<th>Limit for ARFS</th>
<th>n (%)</th>
<th>Severe ARFS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creatinine (μmol l⁻¹)</td>
<td>&lt;120</td>
<td>28 (45)</td>
<td>&gt;120 &lt;240</td>
<td>32 (52%)</td>
<td>&gt;240</td>
<td>2 (3)</td>
<td>need for dialysis</td>
</tr>
<tr>
<td>Urea (mmol l⁻¹)</td>
<td>&lt;8</td>
<td>19 (31)</td>
<td>&gt;8 &lt;16</td>
<td>34 (55%)</td>
<td>&gt;16</td>
<td>9 (15)</td>
<td></td>
</tr>
<tr>
<td>Both apply</td>
<td>normal</td>
<td>28 (54)</td>
<td>ARI</td>
<td>29 (47%)</td>
<td>ARFS</td>
<td>0</td>
<td>5 (8%)</td>
</tr>
</tbody>
</table>

ARI: acute renal injury; ARFS: acute renal failure syndrome. Pre-operative laboratory criteria were only available for 62 of the 69 patients.
conditions like large volumes of blood transfusions can also stress liver function and cause elevated bilirubin values. Liver failure has been identified as a predictor of non-survival in ECLS patients [15]. Our data on liver function do not support a predictive value of the respective laboratory data.

Inflammatory status

A chronic inflammatory state is frequently associated with progressing heart failure. Even if some inflammatory pathways, which involve e.g. nuclear factor-kappaB, may provide protection for the failing myocardium, perpetuating inflammation can promote heart failure [24]. Raised levels of CRP have been shown to be associated with poor prognosis in patients with acute heart failure, provided that there is no concurrent infection [10].

Acid–base balance

Although elevated lactate levels and blood-pH may be indicators for cardiogenic shock, levels are potentially influenced by a variety of other pathophysiological or therapeutic processes. The effect of inotropic medication in combination with fluid and catecholamine regimen has an impact on blood-pH and lactate levels. Furthermore, haemodialysis and respirator therapy allow quick changes of these parameters. The wide variety of lactate and blood-pH levels reported here reflects the everyday scenario of critical care in these patients; however, in our institution the therapeutic decision is not based on these two parameters. Our clinically determined approach is supported by our data which show no difference in the outcome of the patients with respect to the levels of lactate and blood pH.

Limitations of the study

The number of included patients is relatively small, and dispensable data were not collected for every patient. Moreover, we analysed patients with a variety of diseases and indications in terms of a consecutive row of ‘all comers’. Information on previous kidney or liver function was not at hand for many patients. A total of 45% received the ECLS within 48 h after admission to our hospital. For all other patients, indications and in-hospital times before ECLS implantation varied to a large extent. Thus, a reliable analysis of pre-ECLS changes in the laboratory markers was not possible on the basis of our data. Decision for ECLS was made not by means of scores but relied on the multifaceted clinical condition of the patients and the ample experience of the team of cardiovascular surgeons, perfusionists and ICU staff. For outcome analysis, we chose an arbitrary cut-off at 4 weeks after explantation of the ECLS since afterwards the patients die usually due to other causes than to those which led to ECLS. Moreover, our data do not reflect the ‘natural course’ of ECLS because almost one-fifth of patients were bridged to long-term VADs or total artificial hearts.

CONCLUSION

Our data show that renal and hepatic insufficiency, increased inflammatory state and deranged acid–base balance as determined by pre-operative laboratory data are not associated with poor outcome of ECLS. Further, survival is not related to indication for ECLS. The decision for ECLS is still difficult and depends on numerous measurable and not measurable parameters. In a number of patients, ECLS allows for successful bridging to other treatment options.

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REFERENCES

Appendix. Conference Discussion

Dr M. Buijsrogge (Utrecht, Netherlands): This is a single-centre, retrospective, small population study which has some inherent confounding factors regarding age (you mentioned that already), gender, timing of ECMO implantation, co-morbidities, pulmonary function, cerebral function, etc. This might jeopardize the general conclusion that renal kidney function in the acute stage before ECMO implantation is not related to mortality in the long term. Your first comment on that one.

My second question relates to the absolute values of renal and liver function. We all know that the relative values of liver and kidney function on post-op ECMO implantation are indeed related to mortality in the short and in the long term. Do you think that, if you look at the relative predictors or relative parameters relating to liver and kidney function, especially the decrease in liver or kidney function, it might alter your conclusions?

And my last question relates to the rise in hospital costs and limited medical resources. Could you give us as surgeons a predictive value which kidney function, it might alter your conclusions?

Dr Heilmann: Yes. We have many patients that get their ECLS right away when they arrive at the hospital; we would prefer to have prior data, but in most of cases we do not have it.

Dr Buijsrogge: Okay.

Dr Heilmann: We, in practice, have seen that age is really a predictor, so probably that should be considered when a patient is really old. But I think one of the reasons for the less good ECLS outcomes reported by every centre is that we all really just try to rescue the patients, and so we sometimes choose the wrong patient, and end up with an expiration.

Dr Buijsrogge: Your patient with renal failure syndrome was the one who died but you could not give us some cut-off value in a pre-op setting regarding liver and kidney function which is related to a really unsuccessful outcome or mortality in the short or long term.

Dr Heilmann: Well, when we started this analysis, we thought we would find something; but we did not. And even of the five patients that were on dialysis, one did well.

Dr C. Schmitz (Munich, Germany): Do you reject patients due to expected bad outcome?

Dr Heilmann: Yes.

Dr Schmitz: And why? Age? What are your criteria?

Dr Heilmann: There is no single parameter. It is age, it is prognosis. It is the patient’s decision sometimes, and the family’s, if you have the time to ask all of them together. There is no clear cut-off.

Dr D. Loisance (Paris, France): The big issue with ECLS is that it is too easy to implant, and it is not expensive. Consequently, it is used liberally; therefore we should not be surprised by the high rate of catastrophic outcomes. Coming back to your paper, I am concerned because you are mixing everything - apples and pears. There are major differences between post-operative low cardiac output syndrome and primary cardiogenic shock. So you should analyse the results separately in the different groups of patients. I agree that it will be difficult since you will end up with small numbers. So what is your feeling about that?

Dr Heilmann: It is true that there are different indications, and the only solution would be a multicentre study because the values of the numbers are always small in each centre, so we need to pool them.

Dr Loisance: Yes. I have been fighting for years to start a European-perspective randomized trial comparing medical therapy, ECMO and planned BiVAD, but for reasons which are not very clear to me, it is impossible to do this kind of study.