Leucocyte depletion during cardiac surgery: a comparison of different filtration strategies

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The results of leucocyte filtration during cardiac surgery are conflicting. This may be due to timing and duration of the filtration procedure, and to flow and pressure conditions in the filter. Therefore, we prospectively compared three major leucocyte filtration strategies in cardiac surgical patients. Forty patients were randomly divided into four groups. Group I: leucofiltration of arterial blood throughout cardiopulmonary bypass (CPB) (associated with high-flow and pressure gradients), Group II: leucofiltration of a part of the venous return blood in the re-warming phase during CPB (associated with intermediate flow, but high pressure), Group III: leucofiltration of residual heart-lung machine blood during transfusion into the patient after CPB (associated with low flow and low pressure), Group IV: control group without leucofiltration. We measured circulating leucocyte counts, plasma elastase levels and arterial blood oxygenation. Filters were postoperatively examined using scanning electronmicroscopy (SEM). Leucocyte counts increased over time and oxygenation decreased in all groups, without significant differences between the groups. SEM demonstrated extensive protein deposits and damaged leucocytes in the deeper layers of the filters from Group I. This was not observed in the filters from Group III. The postoperative plasma elastase levels increased in Groups II and IV and decreased in Groups I and III. In conclusion, we could not demonstrate a clinical difference among the three leucocyte depletion strategies. However, our laboratory results suggest that leucocyte filtration at low flow and pressure conditions is associated with less leucocyte damage and less release of elastase. Perfusion (2003) 18, 31–38.

Introduction

Cardiopulmonary bypass (CPB) leads to a well-known systemic inflammatory response and contributes to postoperative morbidity and organ dysfunction.¹⁻³ Polymorphonuclear leucocytes and complement are activated as a result of blood contact with the surface of the CPB circuit and are considered important causes for organ dysfunction, notably of the lungs.⁴⁻⁶ Leucocyte depletion by means of filtration has been introduced into clinical practice to reduce this inflammatory response. However, the reported clinical results of leucofiltration are conflicting. Some studies demonstrate a reduction in leucocyte counts⁷⁻¹³ and an improvement in ventilatory parameters,⁷,⁸ whereas others do not.¹⁴⁻¹⁷ These differences may be caused by the timing and duration of the filtration procedure during the operation, and the location of the filter in the CPB circuit. For instance, filtration may be applied throughout CPB,⁷,¹⁰,¹³⁻¹⁵ or in short, but well-aimed, time spans,⁹,¹²,¹⁶ on the arterial,⁷,⁹,¹⁰,¹²⁻¹⁵ or venous¹¹ side of the CPB circuit; or even outside the CPB circuit, as for filtration of residual heart-lung machine blood.⁸ In addition, these various filtration procedures are associated with different flow and pressure conditions over the filter. Filters used under high pressure and flow conditions (e.g., arterial line filters) may have other characteristics of leucocyte entrapment than filters used under low pressure and flow conditions (e.g., filters for residual heart-lung machine blood). It is not known how these factors affect the filter efficiency.

Therefore, in this study, we compared the clinical effects of leucofiltration via the arterial line throughout CPB, leucofiltration via the venous line during re-warming and leucofiltration of residual heart-lung machine blood after CPB. These are the three major strategies for leucofiltration during cardiac surgery, each associated with a different volume

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filtered and with different flow and pressure conditions. In an attempt to study the effects of flow and pressure conditions during filtration, we also examined filters after use with scanning electron microscopy (SEM).

Materials and methods

Patients and filtration procedures

After institutional human investigation committee approval and patient consent, 40 patients scheduled for elective coronary artery bypass grafting (CABG) or valve replacement were randomly allocated to four groups of 10 patients each. Exclusion criteria were pre-existing lung disease, emergency operation and re-operation. In Group I, leucofiltration was achieved throughout CPB using a high-flow leucocyte removal filter (LG6, Pall Biomedical, Portsmouth, UK) incorporated in the arterial line. This procedure was associated with high-flow and pressure gradients over the filter. In Group II, leucofiltration of a part of the venous return blood was achieved during CPB in the re-warming phase until aortic crossclamp release using paired leucocyte removal filters (RS 1, Pall Biomedical, Portsmouth, UK) as previously described. Blood flow was adjusted with a separate roller pump to 400 mL/min. The filtration pressure, measured between the pump and the filter, was generally high (>150 mmHg), but did not exceed 300 mmHg. The filtration procedure lasted 10 ± 0.7 minutes and, thus, the amount filtered was 4000 ± 80 mL. This procedure was associated with intermediate flow, but high pressures. In Group III, leucofiltration of the residual heart-lung machine blood (1.2–2.0 L) was achieved as it was transfused into the patient after CPB using a leucocyte removal filter (RS 1, Pall Biomedical, Portsmouth, UK). The blood was transfused under gravity ≤100 mmHg. This procedure was associated with low flow and low pressures. In Group IV, no leucofiltration was applied. These patients served as controls.

Methods

Anaesthesia was induced and maintained by intravenous infusion of sufentanil (1–3 μg/kg) and midazolam (0.05–0.1 mg/kg). Pancuronium (0.1 mg/kg) was used for muscle relaxation. Ventilatory management was aimed at normocapnia throughout the operation and in the intensive care unit (ICU), with an inspiratory oxygen fraction of 0.4, a positive end-expiratory pressure of 6–8 cmH₂O and a tidal volume of 6–8 mL/kg. Dexamethasone (1 mg/kg) was administered after induction. Bovine lung heparin (300 IU/kg) was used for anticoagulation. This was monitored by the celite-activated clotting time (International Technidyne Co., Edison, NJ, USA) and maintained at a value of at least 400 s. After CPB, heparin was neutralized by protamine (300 IU/kg).

The extracorporeal circuit consisted of roller pumps (Stöckert Istrumnete GmbH, München, Germany) and a membrane oxygenator (CML Excel, Cobe Laboratories, Lakewood, CO, USA) primed with 500 mL hydroxyethyl starch 10% (Haes, Fresenius, Bad Homburg, Germany) and 1500 mL lactated Ringer’s solution. Arterial line filters other than the one studied were not used. Flow rate was adjusted to 2.4 L/m²/min. Blood pressure during CPB was kept between 50 and 80 mmHg and nasopharyngeal temperature was maintained at 30°C. The surgical wound suction blood was returned to the cardiology reservoir of the CPB circuit in all patients. Cell savers were not used. The residual heart-lung machine blood after CPB (±1.3 L) was transfused into the patients in all groups.

Scanning electron microscopy

Histological examination of the leucocyte filters by SEM was performed as previously described. Briefly, after filtration, three filters in each group were rinsed with 500 mL normal saline by a roller pump at a flow rate of 100 mL/min. After rinsing, each filter was opened and two samples of the filter medium were taken. Each sample was divided into three layers; a superficial layer where the blood entered the filter, a middle layer and a deep layer where the blood left the filter. All samples were immediately fixed in a 2% glutaraldehyde solution with 0.1 M cacodylate buffer at pH 7.4. Further processing consisted of standard SEM preparation, including fixation with 1% osmium tetroxide, dehydration in ethanol series, critical point drying and gold sputter coating. The samples of the three layers were subsequently studied with SEM (JEOL 6301F, Tokyo, Japan) by two independent observers to obtain a qualitative assessment of the filter characteristics.

Clinical Measurements

Blood samples for laboratory tests and biochemical assays were drawn from the radial artery of the patient after induction of anaesthesia, at the end of the operation, after three hours in the ICU and on the morning of the first postoperative day. The arterial oxygen tension (PaO₂) and the alveolar-arterial (A-a) oxygen gradient were calculated using standard formulae. From EDTA-anticoagulated blood, haematocrit and platelet, total white blood cell and granulocyte counts were determined by an
electronic cell counter (Cell-Dyn 610, Abbott, Santa Clara, CA, USA). Plasma elastase, as a marker of leucocyte activation, was determined using an enzyme immunoassay (Merck, Darmstadt, Germany).

Perioperative fluid balance, use of inotropic agents, myocardial infarctions (defined as new Q-wave on the ECG and CK > 180 U/L with CK-MB > 10% of total), duration of postoperative intubation, and length of stay in the ICU and the hospital were recorded from the patient charts. The attending ICU and hospital staff were blinded to the study group.

Statistics
All data are presented uncorrected for haemodilution and expressed as mean ± standard error, except for elastase for which percentages are used because of a high range of starting values. For comparison between the groups, one way analysis of variance (ANOVA) was used with a post-hoc analysis, using the Bonferroni method when necessary. To determine the effects of time and interaction between the groups over the different time points, repeated measurements ANOVA was used. To correct for non-sphericity, Greenhouse-Geisser (s) adjustments were made. A p-value ≤ 0.05 was considered statistically significant.

Results
Clinical course
The patient groups were similar with respect to demographic data (Table 1). The CABG patients typically had three grafts of which at least one was an arterial graft. Intubation times, length of stay in the ICU and the hospital, use of inotropes (dopamine, 5–8 mg/kg/min), postoperative blood loss and the overall postoperative fluid balance were similar among the patient groups (Table 2). One patient in Group I had a myocardial infarction. Two patients died: one patient in the control group (IV) who developed a low output state and respiratory insufficiency, and one patient in the arterial group (I) who had massive gastrointestinal bleeding on the ward.

The PaO₂ decreased in the four groups over the different time points with a significant time effect

Table 1 Patient characteristics

<table>
<thead>
<tr>
<th>Group</th>
<th>Arterial (I)</th>
<th>Venous (II)</th>
<th>Residual (III)</th>
<th>Control (IV)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>68.4 ± 2.6</td>
<td>66.2 ± 2</td>
<td>61.4 ± 2.5</td>
<td>66.9 ± 3.4</td>
<td>0.30</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>170 ± 2.5</td>
<td>170 ± 1.5</td>
<td>171 ± 2.9</td>
<td>171 ± 2.3</td>
<td>0.97</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>80.4 ± 2.7</td>
<td>72.1 ± 2.3</td>
<td>75.7 ± 4</td>
<td>75.6 ± 3.6</td>
<td>0.35</td>
</tr>
<tr>
<td>Male (n)</td>
<td>6</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Valve (n)</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>CPB time (min)</td>
<td>126 ± 18.3</td>
<td>110 ± 9.9</td>
<td>99 ± 8.5</td>
<td>113 ± 17.1</td>
<td>0.62</td>
</tr>
<tr>
<td>Filtrate (L)</td>
<td>598 ± 95</td>
<td>4 ± 0.1</td>
<td>1.7 ± 0.1</td>
<td>0</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

Filtrate in the arterial group (I) was calculated from CPB time and a pump flow of 2.4 L/min/m². Filtrate in the venous group (II) was calculated from the start of re-warming to aortic crossclamp release (= 10 ± 0.7 min). Data are shown as mean ± standard error; one way analysis of variance was used for statistical analysis.

Table 2 Postoperative data

<table>
<thead>
<tr>
<th>Group</th>
<th>Arterial (I)</th>
<th>Venous (II)</th>
<th>Residual (III)</th>
<th>Control (IV)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBC-day1 (× 10⁹/L⁻¹)</td>
<td>11.5 ± 0.6 (10.1–13)</td>
<td>16.6 ± 1.3 (13.5–19.7)</td>
<td>13.1 ± 0.8 (11.3–15)</td>
<td>14.4 ± 1.4 (11.3–17.5)</td>
<td>0.04</td>
</tr>
<tr>
<td>PMN-day1 (× 10⁶/L⁻¹)</td>
<td>10.9 ± 1.2 (8.5–13.3)</td>
<td>14.7 ± 1.2 (12.2–17.3)</td>
<td>12 ± 1.9 (9.9–14.2)</td>
<td>14 ± 1.2 (11.6–16.4)</td>
<td>0.03</td>
</tr>
<tr>
<td>PaO₂-day1 (kPa)</td>
<td>13.2 ± 1.2 (10.6–15.8)</td>
<td>11.3 ± 1.9 (19–13.6)</td>
<td>13.8 ± 1.2 (11.1–16.5)</td>
<td>13.2 ± 0.9 (11.2–15.3)</td>
<td>0.47</td>
</tr>
<tr>
<td>A-a grad-day1 (kPa)</td>
<td>18.8 ± 1.2 (16.1–21.5)</td>
<td>21.4 ± 1.4 (19.2–23.7)</td>
<td>18.5 ± 1.2 (15.8–21.2)</td>
<td>18.7 ± 0.8 (16.9–20.6)</td>
<td>0.31</td>
</tr>
<tr>
<td>Intubation (h)</td>
<td>26.1 ± 10.6 (2.1–50.1)</td>
<td>12.5 ± 1.8 (8.4–16.6)</td>
<td>13 ± 1.5 (9.5–16.5)</td>
<td>25.2 ± 11.2 (0.5–50.5)</td>
<td>0.44</td>
</tr>
<tr>
<td>Fluid balance (mL)</td>
<td>−146 ± 408 (−1070–778)</td>
<td>−13 ± 456 (−1064–1038)</td>
<td>412 ± 444 (−593–1418)</td>
<td>899 ± 330 (153–1645)</td>
<td>0.33</td>
</tr>
<tr>
<td>Blood loss (mL)</td>
<td>705 ± 159 (344–1067)</td>
<td>751 ± 117 (480–1021)</td>
<td>676 ± 164 (304–1048)</td>
<td>735 ± 154 (387–1084)</td>
<td>0.98</td>
</tr>
<tr>
<td>ICU stay (hours)</td>
<td>35.7 ± 11.8 (9–62)</td>
<td>28.1 ± 3.4 (20.5–35.7)</td>
<td>23.4 ± 0.6 (22–24.9)</td>
<td>34.9 ± 12.1 (7.5–62.4)</td>
<td>0.71</td>
</tr>
<tr>
<td>Hospital stay (days)</td>
<td>12.5 ± 3.5 (5.6–19.4)</td>
<td>9.1 ± 1.5 (5.6–12.6)</td>
<td>7.8 ± 0.4 (6.8–8.8)</td>
<td>12.3 ± 2.4 (7–17)</td>
<td>0.30</td>
</tr>
</tbody>
</table>

WBC-day1 is the circulating leucocyte count on the first postoperative day. PMN-day1 is the circulating granulocyte count on the first postoperative day. PaO₂-day1 is the arterial oxygen tension on the morning of the first postoperative day. A-a grad-day1 is the alveolar-arterial oxygen gradient on the first postoperative day. Intubation is the duration of postoperative ventilation. Fluid balance is the difference in total fluid input and total fluid output during the first 24 hours. Blood loss is chest tube drainage in the first 24 hours. Data are shown as mean ± standard error and between brackets the 95% confidence limits; one way analysis of variance was used for statistical analysis.
Although the residual group (III) had higher postoperative mean values than the other groups, a significant group effect was not present \((p = 0.53,\text{ Figure 1})\). The \(\text{PaO}_2\) values on the first postoperative day were similar in all groups (Table 2). The postoperative A-a gradients increased with a significant time effect \((p < 0.001)\). Although Group III had the lowest mean values, a significant group effect was not present \((p = 0.62, \text{Figure 1})\). The A-a gradients on the first postoperative day were similar in all groups (Table 2).

**Haematology and biochemistry**

The leucocyte counts increased in all groups from the end of CPB towards the first postoperative day with a significant time effect \((p < 0.001)\). There was no difference between the groups \((p = 0.91)\). The lowest leucocyte counts on the first postoperative day were observed in the residual group (III) and in the arterial group (I). There was a significant difference between the leucocyte counts in Group I and the venous group (II) on the first postoperative day (Table 2, Figure 2). The granulocyte counts also increased, showing a significant time effect \((p < 0.001)\), but no difference between the groups \((p = 0.07)\). There was a significant difference between the granulocyte counts in Group I and Group II on the first postoperative day (Table 2, Figure 2). Analysis of the results with the type of operation, i.e. CABG or valve replacement, as a cofactor revealed a significant \((p < 0.04)\) effect on the leucocyte and granulocyte counts. The platelet counts decreased at the end of the operation and then gradually increased, showing a significant time effect \((p < 0.001)\), but no group effect by repeated measurements analysis of variance. Platelet counts showed a significant decrease over time \((p < 0.001)\), but no group effect by repeated measurements analysis of variance. * \(p < 0.05\) between Group I and Group II by analysis of variance.

**Figure 1** Pre- and postoperative arterial oxygen tension (\(\text{PaO}_2\)) and alveolar-arterial (A-a) oxygen gradients in the three leucocyte filtration groups and in the unfiltered control group at an inspiratory oxygen fraction of 0.4. Pre op = preoperatively, end op = at the end of operation, 3h ICU = at three hours in the intensive care unit, day 1 = the morning of the first postoperative day. Group I: leucocfiltration of arterial blood throughout CPB; Group II: leucocfiltration of a part of the venous return blood during re-warming; Group III: leucocfiltration of residual heart-lung machine blood after CPB; Group IV: controls without leucocfiltration. Values shown are the means, estimated by the repeated measurement model with standard error. The \(\text{PaO}_2\) showed a significant decrease over time \((p < 0.001)\), but no group effect by repeated measurements analysis of variance. The A-a gradients showed a significant increase over time \((p < 0.001)\), but no group effect by repeated measurements analysis of variance.

**Figure 2** Pre- and postoperative circulating leucocyte, granulocyte and platelet counts in the three leucocfiltration groups and in the unfiltered control group. Pre op = preoperatively, end op = at the end of operation, 3h ICU = at three hours in the intensive care unit, day 1 = the morning of the first postoperative day. Group I: leucocfiltration of arterial blood throughout CPB; Group II: leucocfiltration of a part of the venous return blood during re-warming; Group III: leucocfiltration of residual heart-lung machine blood after CPB; Group IV: controls without leucocfiltration. Values shown are the means, estimated by the repeated measurement model with standard error. Leucocyte and granulocyte counts showed a significant increase over time \((p < 0.001)\), but no group effect by repeated measurements analysis of variance. Platelet counts showed a significant decrease over time \((p < 0.001)\), but no group effect by repeated measurements analysis of variance. * \(p < 0.05\) between Group I and Group II by analysis of variance.
nificant time effect \((p < 0.02)\), but no group effect \((p = 0.54)\). The elastase values decreased after the operation in Group III and Group I. Analysis revealed a significant time effect \((p < 0.01)\), but no group effect \((p = 0.61)\). There was a significant difference in elastase levels on the first postoperative day between Group II and Group III \((p < 0.03)\) and between Group III and Group IV \((p = 0.04)\).

**Scanning electronmicroscopy**

The arterial filter (Group I) had fibres of about 15 \(\mu\)m diameter and wide interspaces of about 70 \(\mu\)m. The filter had a three-dimensional structure based on a mesh of single fibres. Extensive platelet and protein deposits almost completely covered the filter fibres and trapped cells (Figure 4 a1). Many platelets, but very few leucocytes, were trapped in the superficial layer of the filter. In the two deeper layers of the filter, many leucocytes and red blood cells were present, often damaged, as shown by the rough, irregular shape (Figure 4 a2). Some red blood cells were caught in the protein network. Platelets had pseudopodia, indicating activation (Figure 4 a2). Platelet deposition decreased in the deeper layers of the filter.

The venous (Group II) and residual (Group III) filters had fibres of about 3 \(\mu\)m diameter, with narrow interspaces of about 10 \(\mu\)m. These filters had a similar three-dimensional structure to the arterial filter. Two distinct cellular patterns were observed, depending on the pressure applied. In the filters used under high pressure, extended protein deposits were seen including fibrin networks (Figure 4 b1). Leucocytes were mainly trapped in the middle and lower layers of the filter, where some damaged leucocytes were also present (Figure 4 b2 and b3). The platelets had a predominantly rounded appearance (Figure 4 b2), but, in the superficial layer, many platelets had pseudopodia (Figure 4 b1). In contrast, in the filters used under low pressure, leucocytes and platelets were predominantly located in the superficial filter layer. Leucocyte and platelet entrapment was grossly reduced in the middle layer. In the lower layer, hardly any leucocytes or platelets were seen (Figure 4 c). There were virtually no protein deposits. Only the platelets in the superficial layer had pseudopodia. Leucocytes were in excess of the platelets.

**Discussion**

In the cardiac surgical patients studied, we did not find a clinical difference among the three filtration groups. Furthermore, there was no clinical difference between any of the filtration groups and the control group where no leucocyte filtration was applied. As such, this study is essentially a negative one with respect to leucocyte filtration. However, the finding of different patterns of leucocyte entrapment with different pressure and flow conditions is new and may explain some of the controversies that exist about clinical leucocyte filtration.

The first leucocyte filtration strategy for cardiac surgical patients, which is currently the most common, is an arterial line filter used throughout CPB. However, the effects on leucocyte counts and \(\text{PaO}_2\) resulting from this approach are conflicting.\(^7,14\) We could not demonstrate a beneficial effect of arterial line filtration on postoperative leucocyte counts, \(\text{PaO}_2\) and A-a gradients in this study. These findings are supported by others.\(^10,14,15\) At least two explanations can be found in the interpretation of the SEM data. First, the leucocytes that are bound in the arterial line filter remain in the circulation and, thus, are subjected to the high pressures, up to 200 mmHg, and high-flows of 4–5 L/min generated in the CPB circuit. The SEM data showed extensive protein deposits and leucocytes that were pressed into the middle and lower filter layer. These pressure and flow conditions can also explain the damaged leucocytes that we found on SEM, and the increased elastase levels that we found at the end of CPB. This is in agreement with Mihaljevic et al. who measured the elastase levels before and after the arterial line filter and found an increase after the filter\(^14\) and with Mair et al. who also found.
increased elastase levels at the end of CPB in their filter group.\textsuperscript{10} Secondly, despite the large blood volume filtered, the leucocyte counts at the end of the operation were similar to the leucocyte counts in the other groups, indicating that the arterial line filter had a low efficiency and efficacy. Again, an

Figure 4 Scanning electronmicroscopic pictures from leucocyte filters under different pressure and flow conditions. The columns show the three different conditions as indicated. The rows show the three layers into which the filters were divided. At the top row, blood entered the filter, at the bottom row, blood left the filter. Note the differences in fibre thickness and interspaces between the different filters (column a vs. b and c), the extensive protein deposit in the arterial filter (column a) and the absence of cells and deposit in the low pressure venous filter (c3). The white bar in the photographs indicates 10 μm. B = red blood cell, L = leucocyte, P = platelet, Pr = protein deposit.
explanation may be found in the SEM data, which show a filter with thick, wide-spaced fibres. Moreover, the short contact time between leucocyte and filter material caused by the high blood flow may play a role as well, since an increase in contact time between leucocytes and filter material improves filtration efficiency.\textsuperscript{18}

In the second strategy, the filter was placed in a side-branch of the venous line of the CPB circuit in order to create low-flow conditions. This approach increased the contact time between the blood and the filter to remove leucocytes more effectively and had the advantage that the leucocytes caught in the filter were completely removed from the circulation after a short period of time. However, this approach did not result in clinically beneficial effects for at least two reasons. First, the procedure often resulted in high pressures due to the design of the filter circuit with paired transfusion filters. As can be seen from the SEM data, the leucocytes were pressed into the deeper filter layers, as with the arterial line filters. This could explain why this filtration procedure, despite the low flow, resulted in high elastase levels after the operation. Secondly, this filtration procedure lasted only about 10 minutes, which was probably too short to produce significant clinical effects. This is supported by the fact that this procedure resulted in high levels of circulating leucocytes and granulocytes on the first postoperative day.

The third strategy, to filter the residual heart-lung machine blood before transfusion into the patient, was based on the fact that blood that is transfused into the patient first passes the lung. The lungs are vulnerable after CPB and also have to filter the transfused, activated blood.\textsuperscript{19} In this setting, low-flow and low-pressure conditions were present as the blood was transfused under gravity. Indeed, the SEM data showed undamaged leucocytes, located on the surface of the filter, and no protein deposits. This may explain the observed low elastase levels on the first postoperative day.

Two shortcomings of this study exist. The first one is related to the filters used. For safety reasons, we used different filters (LG6 and RS1). This may have influenced our results, despite the fact that the chemical composition of the filter material was similar. This factor was, in our opinion, of less importance, as we wanted to compare the different strategies of leucofiltration which are closely linked to differences in volume filtered and type of filter used. More importantly, however, may be the fact that, after prolonged use, leucocyte-depletion filters become saturated as a result of massive cell deposition. For the arterial line filter, this can occur after one hour of use. Despite the fact that the mean CPB times in Group I, as a whole, were longer than that, we did not notice an extreme increase in arterial line pressure during CPB. However, we cannot exclude that the longer CPB times in Group I may have influenced the results of the arterial line filtration negatively. The second shortcoming is that this study is underpowered to detect clinical differences between the groups, due to the small sample size and the fact that coronary artery surgery and valve operations were both included. This can be deduced from the 95\% confidence intervals from Table 2. Most studies included only coronary artery bypass grafting. However, we wanted to demonstrate effects on a mixed population as is usual clinical practice.

In conclusion, in this study, we could not demonstrate a clinical difference between the filtered groups and between the filtered groups and the unfiltered control group. However, the electronmicroscopic data show that the amount of debris is a function of flow and pressure conditions. The results of this study also suggest that pressure might be more important than flow with respect to the leucocyte damage. This study also raises the question whether the filter itself caused the damaged cells, in other words made debris out of normal cells. Future larger scale studies are, therefore, necessary to evaluate the combined effects from different leucocyte depletion strategies on the filters and their clinical implications.

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References


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