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Efficacy of the RemoweLL cardiotomy reservoir for fat and leucocyte removal from shed mediastinal blood: a randomized controlled trial

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Abstract

Introduction: Re-transfusion of lipid particles and activated leucocytes with shed mediastinal blood (SMB) can aggravate cardiopulmonary bypass-associated inflammation and increase the embolic load. This study evaluated the fat and leucocyte removal capacity of the RemoweLL cardiotomy reservoir.

Methods: Forty-five patients undergoing elective on-pump cardiac surgery were randomly allocated to filtration of SMB using the RemoweLL or the Admiral cardiotomy reservoir. The primary outcome was a drop in leucocytes and lipid particles obtained with the two filters. The effect of the filters on other blood cells and inflammatory mediators, such as myeloperoxidase (MPO), was also assessed.

Results: The RemoweLL cardiotomy filter removed 16.5% of the leucocytes ($p<0.001$) while no significant removal of leucocytes was observed with the Admiral ($p=0.48$). The percentage reductions in lipid particles were similar in the two groups (26% vs 23%, $p=0.2$). Both filters similarly affected the level of MPO ($p=0.71$).

Conclusion: The RemoweLL filter more effectively removed leucocytes from SMB than the Admiral. It offered no advantage in terms of lipid particle clearance.

Keywords

leucocyte removal; lipids; filtration; cardiotomy reservoir; cardiopulmonary bypass

Introduction

Cardiopulmonary bypass (CPB) induces a systemic inflammatory response syndrome (SIRS) from various mechanisms, including the contact between blood and the surface of the extracorporeal circuit, operative trauma, ischaemia-reperfusion and blood-air interface.[1] This inflammatory response involves the activation of several cells and systems, including the complement, leucocytes and the endothelium. By releasing cytokines and enzymes such as elastase and myeloperoxidase (MPO), activated leucocytes damage the endothelium, increase vascular permeability and, potentially, contribute to organ dysfunction.[1–3]

Reinfusion of pericardial suction blood is a common, but controversial practice during CPB.[4] Pericardial suction blood contains free haemoglobin,[5] activated leucocytes, inflammatory mediators[6] and fat

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particles.[7,8] As a consequence, re-transfusion of pericardial suction blood aggravates CPB-associated SIRS[9,10] and increases the lipid embolic load.[11] Therefore, avoidance of direct re-transfusion of unprocessed shed mediastinal blood (SMB) is recommended.[12]

Cell saver recycling[13] and leucocyte and fat filtration were proposed to mitigate the pathological effects of the re-transfusion of pericardial suction blood. Centrifugal washing has the disadvantage of losing coagulation factors and can, potentially, increase postoperative bleeding and transfusion.[14] Fat and leucocyte filtration is an appealing alternative. However, no filtering device has proven able to offer a clinically meaningful reduction in lipid microemboli so far.[4]

The RemoweLeucoLipids (RemoweLL, Eurosets, Medolla, Italy) is an innovative device that contains a filtering layer and supernatant separator designed for both leucocyte removal and lipid filtration. The suction blood first passes through the filter before reaching an internal chamber where the supernatant is sequestered. The aim of the present study was to assess the efficacy of the RemoweLL reservoir (Eurosets, Italy) to remove fat particles and leucocytes from shed mediastinal blood. The Admiral cardiotomy reservoir (Eurosets, Italy), which has a similar design, but only incorporates a 40-μm filter, was used as a comparator.

Materials and Methods

Patients and Randomization

The study was approved by our institutional ethics committee (Ref. B707201111784) and all patients gave written informed consent to participate. Forty-five patients scheduled for elective on-pump cardiac surgery at the CHU of Liège between October 2013 and February 2015 were prospectively enrolled. Inclusion criteria were age between 40 and 80 years, left ventricular ejection fraction (LVEF) >30% and male gender. Exclusion criteria were emergency surgery, weight <65 kg, coagulopathy, previous cardiac surgery, collection of less than 300 mL of SMB during the CPB procedure and preoperative anaemia defined by a haemoglobin level <12 g/dL. Sealed envelopes were used to randomly allocate patients to the RemoweLL group (test group) or the Admiral group (control group).

Clinical Management

Anaesthesia was induced and maintained using target-controlled infusions of propofol and remifentanil. Full muscle relaxation was achieved with 1 mg/kg of rocuronium before tracheal intubation. An intravenous bolus of 2.5 gr of tranexamic acid was administered before the initiation of CPB and repeated after complete separation and protamine administration. All procedures were performed using an SIII roller pump (Stöckert, Sorin Group Inc., Munich, Germany). Phosphorylcholine-coated circuits with an integrated hollow-fibre oxygenator (A.L.One, Eurosets, Medolla, Italy) were used for all procedures. The priming consisted of 1250 mL of balanced crystalloid (PlasmaLyte A®, Baxter, Lessines, Belgium) with 150 mL of 15% mannitol, 5000 IU of unfractionated heparin and 1 g of tranexamic acid. Before arterial cannulation, full heparinization was achieved with a 300 IU/kg bolus of unfractionated heparin. Boluses of heparin were repeated to keep the activated clotting time (ACT) >480 s (Hemochron Response Whole Blood Microcoagulation Systems, ITC Medical, San Francisco, CA, USA). Intermittent cold crystalloid cardioplegia (St Thomas' solution) was used for myocardial protection. All CPB procedures were conducted in normothermia. During CPB, blood vented from the left ventricle was directly collected into the venous reservoir while SMB was aspirated and filtered in an additional cardiotomy reservoir; the RemoweLL or the Admiral according to the randomization.

Shed Mediastinal Blood

SMB was first aspirated into a flexible bag until a volume of at least 300 mL was obtained. After drawing samples for initial fat and leucocyte numeration, the blood was filtered and stored, either in the RemoweLL or in the Admiral separated cardiotomy reservoir. According to the manufacturer's instructions, a sedimentation time of 40 minutes was allowed to take full advantage of the lipid removal capacity of the filter. Finally, the filtered SMB was directly re-infused into the CPB circuit, except for CABG surgery, where it was treated with the cell saver, according to our institutional protocol. Cases in which collected SMB was less than 300 mL or decantation time shorter than 40 minutes were excluded from the final analyses.

Biochemical Measurements

Full blood count and total triglyceride and cholesterol levels were obtained at the preoperative anaesthesia consultation.

Full blood count and levels of MPO, triglycerides, cholesterol and lipid particles were also obtained at three different times: on an arterial blood sample drawn immediately after the induction of anaesthesia (T0, baseline value), on SMB before filtration (T1) and on filtered SMB after a 40-minute period of decantation (T2). Soluble P-selectin (sPSel) was measured twice: before (T1) and after filtration (T2). Blood samples for

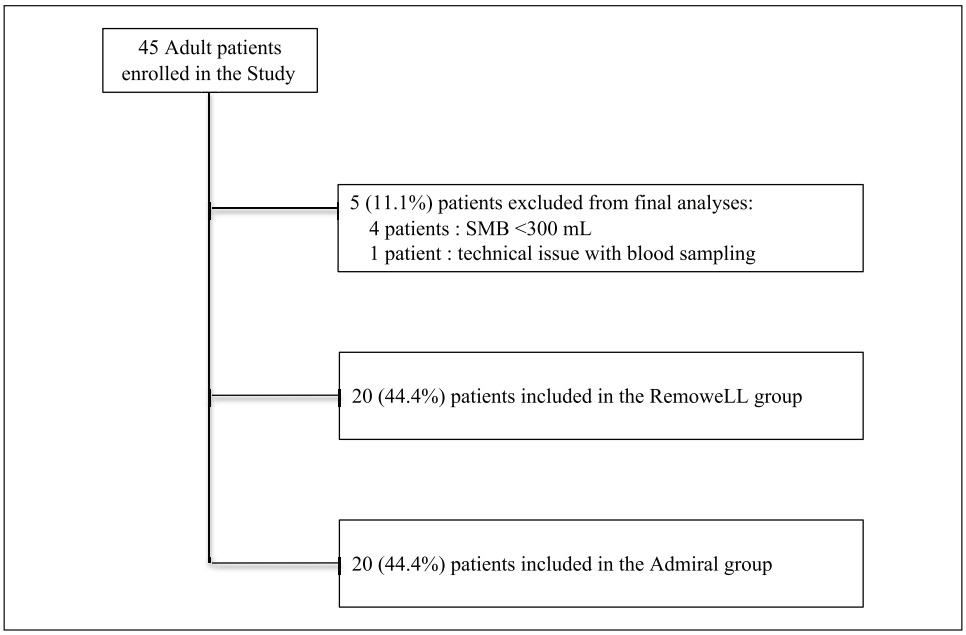

Figure 1. Breakdown of patient groups for analysis.

MPO and sPSel measurements were drawn into sterile vacuum tubes. After centrifugation, the plasma was collected and stored at -80°C until biochemical analyses were performed. Haematological parameters were obtained using the Sysmex XE-5000 instrument (Sysmex, Hoeilaart, Belgium). Lipid particles were numerated as the excess of events detected in the BASO channel compared to the DIFF channel of the XE-5000, as described in the supplier's technical documents. Triglycerides and cholesterol were measured using a COBAS instrument (Roche Diagnostics, Vilvoorde, Belgium). MPO was determined by double immune-enzymometric assay (Gentaur Europe BVBA, Kampenhout, Belgium). Soluble P-selectin was analyzed by a "sandwich" immunoassay technique (R&D Systems Europe, Abingdon, Oxfordshire, UK).

The primary endpoint was the difference in leucocyte and lipid particle drop observed between the two filters. Secondary endpoints included the effects each filter had on the leucocyte count, the amount of lipid particles and other haematological parameters, including the haemoglobin level, the platelet count and the different sub-populations of white blood cells. The effect of filtration on the levels of cholesterol, triglycerides, MPO and soluble P-selectin was also assessed. Eventually, the efficacy of the two filters on the above-mentioned parameters was compared.

Statistical analysis

Normality of the distribution was checked using the Shapiro-Wilk test. Data are presented as the median (interquartile range) or mean (standard deviation) unless otherwise stated. Based on a preliminary sample, we estimated that the inclusion of 20 patients per group would provide an 80% power to detect a 50% reduction in the amount of lipid particles by the RemoweLL at an alpha level of 0.05. We planned to include 45 patients to account for potential drop-out (Figure 1). Between-group comparisons were performed using Student's T test, the Mann-Whitney U test or the Chi-squared test, as appropriate. The non-parametric Wilcoxon's matched-pair signed rank test was used for within-group comparisons. A p-value $\leqslant 0.05$ was considered statistically significant. Statistica (version 10) was used for all statistical analyses.

Results

Forty-five patients were enrolled and randomized to the groups. One patient from the RemoweLL group and three patients from the Admiral group were excluded because the SMB volume did not reach 300 mL. Another patient had to be excluded from the RemoweLL group because of a technical issue with blood sampling. Consequently, 40 patients (20 in each group) were retained for the final analyses (Figure 1). The clinical characteristics, preoperative laboratory tests and surgical procedures were similar in the two study groups (Table 1). The laboratory data, measured immediately after the induction of anaesthesia, did not differ between the groups (Table 2) and there was also no difference in the composition of the SMB before filtration (Table 3).

Table 1. Preoperative and operative clinical data.

Variable	RemoweLL Group n=20	Admiral Group n=20
Age (years)	64.4 ± 9.1	63.9 ± 11.6
BMI (kg/m²)	30.1 ± 5.44	29.0 ± 4.96
BSA (m²)	2.02 (1.93 – 2.12)	2.02 (1.91 – 2.25)
Logistic EuroSCORE1 (%)	1.84 (1.08 – 3.21)	2.36 (1.70 – 3.67)
Hypertension (%)	18 (90.0)	17 (85.0)
COPD (%)	4 (20.0)	5 (25.0)
Angina pectoris (%)	11 (55.0)	11 (55.0)
Previous MI (%)	4 (20.0)	3 (15.0)
Diabetes (%)	6 (30.0)	6 (30.0)
Peripheral arterial disease (%)	2 (10.0)	4 (20.0)
Dyslipidemia (%)	17 (85.0)	15 (75.0)
Preoperative antiplatelet blocker (%)	16 (80.0)	18 (90.0)
Preoperative laboratory data		
Haemoglobin (g/dL)	13.9 (13.4 – 15.0)	14.7 (14.1 – 15.9)
Haematocrit (%)	41.0 (39.6 – 42.4)	43.7 (41.8 – 46.1)
Platelets (10^3/mm³)	201.5 (164.5 – 232.5)	228.0 (202.5 – 283.5)
White blood cells (10^3/mm³)	7.02 (6.23 – 8.48)	8.19 (6.62 – 9.49)
Neutrophils (%)	61.3 (53.6 – 64.4)	58.9 (55.7 – 66.3)
Triglycerides (mg/dL)	143.5 (108.5 – 228.5)	150.0 (123.0 – 218.0)
Cholesterol (mg/dL)	178.5 (154.0 – 202.0)	192.0 (164.0 – 241.0)
Type of surgery		
CABG (%)	11 (55.0)	11 (55.0)
Valve (%)	2 (10.0)	1 (5.00)
Valve + CABG (%)	7 (35.0)	7 (35.0)
Other (%)	0 (0.00)	1 (5.00)
CPB time (min.)	84.5 (71.5 – 112.0)	114.0 (98.5 – 145.5)
Cross-clamp time (min.)	50.0 (40.5 – 74.5)	75.0 (64.0 – 83.0)
Filtration blood (mL)	400.0 (300 – 475)	400.0 (300 – 500)

Data are expressed as mean ± SD or median (25-75th percentiles) and percentages (%).
BMI: body mass index; BSA: body surface area; COPD: chronic obstructive pulmonary disease; MI: myocardial infarction; CABG: coronary artery bypass graft; CPB: cardiopulmonary bypass.

Primary endpoint

The leucocyte reduction was significantly greater with the RemoweLL than with the Admiral (16.5% vs - 0.7%; p<0.001). On the contrary, both filters produced a similar reduction in the amount of lipid particles (26% vs 23%; p=0.2).

Secondary endpoints

The RemoweLL reduced the white blood cells count from 3.73×10^3/mm³ [2.55-4.09] to 3.19×10^3/mm³ [2.03-3.55] (p<0.001) while the Admiral produced no significant leucocyte reduction (1.95×10^3/mm³ [1.29-2.39] vs 2.12×10^3/mm³ [1.16-2.35], p=0.48). The amount of lipid particles was reduced from 1355 ml^{-1} [920-2325] to 895 ml^{-1} [520-1930] (p<0.001) with the RemoweLL and from 1385 [745-2040] to 865 ml^{-1} [455-1675] (p<0.001) with the Admiral. A detailed breakdown of the effect of the RemoweLL on the different sub-populations of white blood cells is presented in Table 4. The leucocyte reduction occurred mainly at the expense of neutrophils, monocytes and eosinophils while basophils and lymphocytes were unaffected. The RemoweLL also slightly, but significantly, reduced the platelet count (p<0.001) which was unaffected by the Admiral (p=0.26). On the contrary, the Admiral produced a small, but statistically significant reduction in the haemoglobin concentration of the filtered blood (p<0.001) while the RemoweLL did not affect the haemoglobin value (p=0.80). Eventually, the two filters significantly and similarly reduced triglycerides and had no effect on cholesterol (Table 4).

MPO levels after filtration increased significantly compared to pre-filtration in the RemoweLL group (p=0.006) and in the Admiral group (p=0.044). Values of soluble P-selectin were not affected by any of the two filters (Table 5).

Discussion

In the present study, processing the mediastinal shed blood with the RemoweLL cardiotomy reservoirs

Table 2. Biological data after induction of anaesthesia (T0).

Variable	RemoweLL Group n=20	Admiral Group n=20	p-value
Haemoglobin (g/dL)	13.2 (12.1 – 14.2)	13.5 (12.9 – 14.3)	0.34
Haematocrit (%)	37.8 (36.0 – 39.8)	39.5 (37.9 – 40.7)	0.13
Platelets (10^3/mm^3)	172.0 (135.0 – 209.5)	202.5 (170.0 – 242.5)	0.07
White blood cells (10^3/mm^3)	6.17 (4.99 – 6.88)	5.84 (4.88 – 6.92)	0.77
Neutrophils (10^3/mm^3)	3.62 (2.84 – 4.08)	3.36 (2.75 – 4.22)	0.79
Lymphocytes (10^3/mm^3)	1.57 (1.38 – 1.81)	1.73 (1.13 – 2.23)	0.58
Monocytes (10^3/mm^3)	0.47 (0.36 – 0.58)	0.56 (0.38 – 0.67)	0.41
Eosinophils (10^3/mm^3)	0.18 (0.13 – 0.31)	0.13 (0.07 – 0.26)	0.14
Basophils (10^3/mm^3)	0.03 (0.02 – 0.05)	0.04 (0.03 – 0.05)	0.43
Triglycerides (mg/dL)	137.0 (108.0 – 216.5)	118.5 (80.0 – 165.5)	0.13
Cholesterol (mg/dL)	150.0 (132.5 – 176.0)	168.5 (144.0 – 202.5)	0.11
Lipid particles (Nbr/mL)	140 (65 – 180)	155 (−15 – 290)	0.68
MPO (ng/mL)	95.8 (74.1 – 116.7)	74.9 (60.6 – 93.7)	0.17

Data are expressed as median (25-75th percentiles).
MPO: Myeloperoxidase.

Table 3. Biological data before and after filtration according to RemoweLL (Test) or Admiral (Control) groups.

Variable		RemoweLL Group n=20	Admiral Group n=20	p-value
Haemoglobin (g/dL)	Before	8.10 (5.65 – 9.75)	7.80 (5.95 – 9.30)	0.75
	After	7.85 (5.65 – 9.30)	7.55 (5.35 – 9.15)	0.53
Haematocrit (%)	Before	23.4 (15.9 – 27.4)	22.3 (16.8 – 27.3)	0.74
	After	23.1 (15.8 – 26.2)	21.1 (15.5 – 25.9)	0.53
Platelets (10^3/mm^3)	Before	135.5 (115.5 – 170.0)	126.0 (109.0 – 181.5)	0.60
	After	120.0 (97.5 – 140.5)	126.5 (110.0 – 174.0)	0.26
White blood cells (10^3/mm^3)	Before	3.73 (2.55 – 4.09)	2.12 (1.16 – 2.35)	0.31
	After	3.19 (2.03 – 3.55)	1.95 (1.29 – 2.39)	0.94
Neutrophils (10^3/mm^3)	Before	2.16 (1.12 – 2.73)	2.12 (1.16 – 2.35)	0.71
	After	1.74 (1.06 – 2.38)	1.95 (1.29 – 2.39)	0.67
Lymphocytes (10^3/mm^3)	Before	0.99 (0.51 – 1.37)	0.69 (0.39 – 1.29)	0.53
	After	1.02 (0.58 – 1.20)	0.77 (0.52 – 1.30)	0.68
Monocytes (10^3/mm^3)	Before	0.14 (0.06 – 0.22)	0.08 (0.06 – 0.19)	0.37
	After	0.07 (0.03 – 0.12)	0.06 (0.03 – 0.10)	0.74
Eosinophils (10^3/mm^3)	Before	0.08 (0.04 – 0.11)	0.05 (0.04 – 0.09)	0.23
	After	0.06 (0.02 – 0.09)	0.06 (0.02 – 0.09)	0.99
Basophils (10^3/mm^3)	Before	0.01 (0.00 – 0.04)	0.01 (0.00 – 0.04)	0.91
	After	0.01 (0.00 – 0.03)	0.00 (0.00 – 0.01)	0.38
Triglycerides (mg/dL)	Before	166.0 (117.5 – 239.0)	138.0 (105.0 – 162.0)	0.23
	After	139.5 (85.5 – 179.0)	104.0 (79.0 – 132.0)	0.14
Cholesterol (mg/dL)	Before	85.5 (74.0 – 123.5)	103.0 (61.0 – 130.0)	0.55
	After	86.0 (74.0 – 115.5)	91.0 (61.0 – 117.0)	0.96
Lipid particles (Nbr/mL)	Before	1355 (920 – 2325)	1385 (745 – 2040)	0.52
	After	895 (520 – 1930)	865 (455 – 1675)	0.36

Data are expressed as median (25-75th percentiles).
Before filtration = T1; After filtration = T2.
MPO: Myeloperoxidase.
p-value: comparison between RemoweLL and Admiral groups - Unpaired statistical test.

resulted in a 16.5% reduction in the leucocyte count and a 26% decrease in the amount of lipid particles. In comparison with the Admiral, another separate cardiotomy reservoir used for shed blood filtration which has a similar surface treatment and design, the RemoweLL achieved a significantly higher degree of leucocyte reduction. On the contrary, in terms of lipid particles, both filters produced a similar reduction.

Table 4. Differences of biological data before and after filtration according to RemoweLL (Test) or Admiral (Control) groups.

Variable	RemoweLL Group n=20	Admiral Group n=20	p-value
Haemoglobin (g/dL)	0.00 (−0.10 – 0.40)	0.25 (0.10 – 0.60)	*0.03*
Haematocrit (%)	0.00 (−0.60 – 1.10)	0.65 (0.30 – 1.55)	*0.01*
Platelets (10^3/mm^3)	13.0 (7.5 – 26.5)	2.50 (−2.50 – 6.50)	*<0.001*
White blood cells (10^3/mm^3)	0.49 (0.24 – 0.76)	–0.02 (−0.07 – 0.11)	*<0.001*
Neutrophils (10^3/mm^3)	0.35 (0.17 – 0.59)	0.07 (−0.11 – 0.22)	*<0.01*
Lymphocytes (10^3/mm^3)	−0.03 (−0.14 – 0.15)	−0.08 (−0.17 – 0.12)	0.41
Monocytes (10^3/mm^3)	0.08 (0.02 – 0.12)	0.02 (0.00 – 0.05)	*0.04*
Eosinophils (10^3/mm^3)	0.02 (0.01 – 0.08)	0.01 (−0.02 – 0.02)	*0.04*
Basophils (10^3/mm^3)	0.00 (0.00 – 0.01)	0.00 (0.00 – 0.03)	0.38
Triglycerides (mg/dL)	36.5 (15.5 – 59.5)	30.0 (12.0 – 61.0)	0.68
Cholesterol (mg/dL)	0.00 (−1.00 – 1.50)	0.00 (−1.00 – 2.00)	0.58
Lipid particles (Nbr/mL)	400 (230 – 670)	245 (130 – 555)	0.22

Data are expressed as median (25–75th percentiles).
Before filtration = T1; After filtration = T2.

Table 5. Soluble P-selectin and myeloperoxidase levels before and after filtration according to RemoweLL (Test) or Admiral (Control) groups.

		RemoweLL Group n=20	Admiral Group n=20	p-value†
sP-selectin (ng/mL)	Before	21.54 (17.86 – 27.55)	21.58 (14.34 – 30.68)	0.60
	After	22.94 (19.70 – 27.46)	20.88 (16.03 – 29.74)	0.58
	Difference	0.54 (−0.79 – 1.69)	0.88 (0.04 – 1.90)	0.35
		p=0.81	*p=0.022*	0.97
MPO (ng/mL)	Before	1037.8 (788.0 – 1849.5)	1000.3 (793.2 – 2015.3)	0.94
	After	1342.1 (986.6 – 1569.4)	1320.1 (727.7 – 2240.9)	0.71
	Difference	212.2 (31.3 – 360.7)	181.9 (−23.1 – 353.2)	
		p=0.006	*p=0.044*	

Data are expressed as median (25–75th percentiles). Before filtration = T1; after filtration = T2.
sP-selectin: soluble P-selectin; MPO: Myeloperoxidase.
p-value†: comparison before-after filtration - Paired statistical test.

The 16.5 percent leucocyte reduction we observed is less than the 35% and 52% reduction reported by Caltavuturo et al. and Dell'Amore et al., respectively.[15,16] Caltavuturo et al. performed their study *in vitro*, using units of packed red blood cells from blood donations stored at 4°C for various periods of time before the study was performed. Dell'Amore et al. used a design similar to the design of the present study, but the leucocyte count measured in the SMB before filtration was much higher in the study of Dell'Amore et al. These differences can account for the discrepancies observed between the results of the different studies since the leucocyte depletion capacity of a filter depends on several factors, including the temperature, the speed blood flows through the filter and the pre-filtration leucocyte count.[17,18]

In terms of lipid particles, the 26% reduction we observed in the RemoweLL group is less that the 63% reduction reported by Dell'Amore et al. However, Dell'Amore et al. used the Thoma-Zeiss chamber for lipid particle quantification, after a dilution process, while we used a measure derived from the XE-5000. Again, these methodological differences can account for the result discrepancies. Accordingly, they reported a median lipid particle count of 280 per mL before filtration while we estimated that the SMB contained 1350 lipid particles per mL. The 26% removal of lipid particles by the RemoweLL device is similar to the filtering capacity of the conventional filter (Admiral) after 40 minutes of sedimentation time. A similar reduction of serum triglycerides was also observed in both groups. The specific design of the RemoweLL, therefore, does not seem to improve lipid particle depletion, despite a prolonged sedimentation time.

These results raise the question of the minimal threshold of clinical relevance for lipid particle and leucocyte filtration. It was previously demonstrated that the amount of lipid particles in SMB can reach 600x10^3/mL. Although there is no data available regarding the minimal amount of reduction that would result in a clinical

benefit, a 20% decrease appears marginal and is probably of questionable clinical relevance.[4]

In addition to leucocytes and fat particles, we also investigated the ability of the filter to remove factors released by the activated leucocytes, such as MPO. Our results first demonstrate that MPO levels in SMB are much higher than on the post-anaesthetic sample, confirming the existence of CPB-induced neutrophil degranulation.[2,3,19] Moreover, MPO levels in SMB were significantly increased by the filtration, regardless of the filter used. This suggests that filtration could have worsened the inflammation associated with SMB re-transfusion.

A significant reduction of platelets was observed in SMB filtered through the RemoweLL device. This could be related to platelet activation due to the prolonged contact between the blood and the filter, platelet trapping by the filter and/or sequestration in the supernatant or both. The absence of an elevation of P-selectin on the post-filtration sample suggests that filtration produced no platelet activation (Table 5).[20] Platelet sequestration is, therefore, a more likely explanation.

The main limitation of this study is that it was only focused on the evaluation of the capacity of the filtration device. Outcome measures like cognitive or renal function and postoperative inflammation were not assessed. It also has a limited sample size of 20 patients per group.

Besides its limited efficacy, the need of a 40-minute sedimentation time with the RemoweLL might be considered as a factor potentially limiting its use. Indeed, it can turn out impractical in the case of a short bypass run or during important bleeding when rapid reinfusion of suction blood is necessary. However, these disadvantages also apply, although to a lesser extent, to other techniques used for fat and leucocyte removal, such as cell salvage.

In conclusion, the RemoweLL filter more efficiently reduced leucocytes in SMB than a traditional filter, without decreasing the concentration of some inflammatory mediators released by activated leucocytes. It also showed no superiority for lipid particle filtration. Further investigations are warranted to determine if the reduction in leucocyte count results in reduced postoperative inflammation or improved patient outcome and to assess the significance of increased levels of myeloperoxidase.

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