In Situ Reconstruction in Native and Prosthetic Aortic Infections Using Cryopreserved Arterial Allografts

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WHAT THIS PAPER ADDS

This study reports the outcome of in situ aortic reconstruction using cryopreserved allografts. It emphasizes the need for close postoperative surveillance because of the substantial early graft-related complication rate. It studies the influence on allograft behavior of two cryopreservation protocols generally reported and used in this series. It also identifies five independent predictors of early mortality: age, chronic kidney disease, coronary disease, prosthetic infection, and urgent procedures.

Objectives: To evaluate overall survival and complications of cryopreserved arterial allografts in aortic graft infections and infected aortic aneurysms.

Methods: A retrospective review of consecutive patients was conducted with native or prosthetic aortic infections, who underwent local debridement and in situ implantation of a cryopreserved aortic allograft from September 2004 to June 2012 at the Henri Mondor University Hospital. Patient characteristics, indications for allograft implantation, perioperative events, bacteriological data, and events related to follow-up were identified. The primary outcome was overall survival. Overall survival was estimated using the Kaplan—Meier method. Predictors of postoperative mortality were identified using uni- and multivariate analysis with a Cox proportional hazard regression.

Results: During the study period, 54 patients (45 [83%] men, mean age 66.2 ± 10.2 years) underwent aortic reconstruction using cryopreserved allografts. Indications were native aortic infection in 17 patients and prosthetic graft infection in 37 patients, including seven aortoenteric fistulae. Twelve aortic reconstructions (22%) were performed as emergency procedures. The median duration of follow-up was 12.1 months (range 0.4—83.6). The 30-day mortality rate was 28%. The overall mortality rate was 39% at a median follow-up of 12.1 months. Early significant postoperative complications occurred in 52% of patients. The graft-related mortality rate was 7%. The graft-related complication rate was 19%. During follow-up, there were two recurrences of aortic infection and two recurrences of allograft limb occlusion. Multivariate survival analysis identified age, chronic renal disease, prosthetic infection, emergent procedure, and coronary disease as independent predictors for postoperative mortality.

Conclusion: This experience with cryopreserved aortic allografts in aortic reconstructions shows an unsatisfactory 30-day survival rate, as well as a substantial early graft-related complication rate. Longer follow-up is needed in order to support the preferential use of cryopreserved allografts based on their long-term behavior.

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INTRODUCTION

The incidence of infected aortic aneurysms, commonly referred to as "mycotic aneurysms" is low and reported to vary from 0.6 to 3.0% of all aneurysms, occurring throughout the aorta, with 50% in the infrarenal position.[1]

Vascular graft infection occurs after 0.2—6.0% of interventions.[2,3] All surgical options share the same principle: to perform radical treatment by excising the infected tissues and material, and to re-establish arterial continuity. Extra-anatomical reconstruction associated in a simultaneous or staged manner with in situ debridement has been long regarded as a reference method. However, in the last decade, reinfection rates and stump pathology have led to growing consideration of in situ replacement using different materials. Cryopreserved arterial allografts offer the advantages of experimental[4,5] and clinical high resistance to

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infection, with the disadvantage of unpredictable availability and possible degenerative change.[4–6]

The aim of this study was to assess the outcome and complications of patients treated with cryopreserved arterial allografts for aortic graft infections and infected aortic aneurysms based on a single center experience.

METHODS

A retrospective review of a prospectively maintained database from September 2004 to June 2012 was conducted. Patients who underwent in situ cryopreserved arterial allograft implantation for a native or prosthetic aortic infection at the Henri Mondor University Hospital were identified. The patient list was crosschecked using the database of the tissue bank that provided the allografts.

Diagnosis was based on clinical and biological findings combined with computed tomography. Specimens for microbiological cultures were obtained before surgery (blood culture and local specimen from infected wounds) and appropriate antibiotic therapy was prescribed accordingly.

Total removal of the infected graft or aortic tissues was performed whenever possible. Tissue samples were obtained for microbiological cultures. The remaining bed was thoroughly irrigated with povidone iodine standard solution diluted in 0.9% isotonic NaCl. Whenever possible, the allograft was covered with a pedicled anterior omentoplasty. Digestive fistulae were treated with the help of visceral surgeons.

Allograft management

Allografts were harvested from brain deceased multiple organ donors. Donor serum samples were screened for HIV-1 and HIV-2 antibodies (p24 antigenemia, HIV RNA polymerase chain reaction [PCR] test), human T-lymphocyte virus 1 and 2, hepatitis B virus (RNA PCR test, hepatitis B antigenemia, anti-HBc antibodies), hepatitis C virus (anti-hepatitis C antibodies, RNA PCR) and syphilis. Bacteriological controls were performed on the liquid storage medium. The sterility of the graft was confirmed by cultures for bacteria and fungi.

After being rinsed with the heparinized saline solution, the allografts were immersed in the cold (4 °C) transfer medium, which was composed of 0.9% sodium chloride and 0.2% glucose (pH 6.8) without antibiotics. The arterial allografts were stored at 4 °C in SCOT solution (Macopharma Laboratories, Tourcoing, France) containing gentamicin (50 mg/mL), clindamycin (600 mg/mL), and vancomycin (500 mg/mL), and cryopreserved within 48–72 hours. They were transferred into freezing bags (Hemofreeze bag Z2012; Fresenius HemoCare, L'Arbresue, France). Cryopreservation solution (100 mL) was added.

Between 1998 and 2002, the cryopreservation solution was composed of 90 mL of a 4% human serum albumin solution and 10 mL of dimethyl sulfoxide (DMSO). After 30 minutes of equilibrium at 4 °C, the bags were placed in a controlled rate liquid nitrogen freezing chamber (Planer, Sunbury-on-Thames, UK) and frozen at a cooling rate of −1 °C/minute to −50 °C, and −5 °C/minute from −50 °C to −140 °C. The frozen grafts were then stored in the vapor phase of liquid nitrogen until use. On the day of transplantation, frozen arteries were rapidly thawed in a 40 °C water bath. After removal of the cryoprotectant, the graft was suspended in 100 mL of 0.9% sodium chloride containing 0.2% glucose.

Since 2002, allografts have been permeated for 20 minutes at 4 °C in SCOT solution containing 15% DMSO and subsequently frozen at −80 °C without rate-controlled freezing, and stored for a maximum of 2 years. At the request of the vascular surgeon, the bag containing the artery remained at room temperature in the operating room for exactly 10 minutes. It was then thawed in prewarmed water (37 °C). Afterwards, the allografts underwent successive washouts in heparinized solution at room temperature. The final washout fluid was sampled for bacteriology culture.

Broad-spectrum intravenous antibiotics were administered during the operation and the early postoperative period, and replaced by oral therapy according to the bacteriological results. Oral antibiotics were administered for 4–6 weeks.

Statistical analysis

A descriptive analysis was performed using mean ± SD or median (interquartile ranges) for continuous variables. For categorical variables, absolute numbers and percentages were computed.

Survival analysis. The primary endpoint was the survival rate, considering two events: death (overall survival) and a composite event defined as death or the occurrence of a postoperative complication (event-free survival). The secondary endpoints were the reintervention rate, the limb salvage rate, the reinfection rate, and the graft patency rate.

Patient survival rates were determined using the Kaplan–Meier method.

The prognostic significance of potential variables was first determined by means of univariate survival analysis (log rank test): all variables yielding p-values $<.20$ were then integrated into a multivariate analysis to adjust for possible confounders, using a Cox proportional hazard regression. The Cox regression used a backward stepwise selection method with a significance criterion set at .05 for inclusion in the model, with non-significant variables being removed at each step of the selection. The association of each variable with the outcome was estimated with hazard ratios (HRs) and associated confidence intervals (CIs). Statistical significance was assumed at $p < .05$; all reported p-values were two-sided.

All statistical analyses were performed with Stata version 11.0 (StataCorp, College Station, TX, USA).

RESULTS

Fifty-four patients (45 [83%] men, nine [17%] women; mean age 66.2 ± 10.2 years) underwent treatment for aortic infection, including 16 mycotic aneurysms, 37 prosthetic graft infections, and one infectious aortitis. Twenty-two (59%) patients with prosthetic infection had the primary procedure performed at the Henri Mondor University

Hospital. Overall, 1,520 open and endovascular aortic procedures were performed during the study period.

The infected segment was the abdominal aorta in 52 cases and thoracic aorta in two.

Of the 37 prosthetic infections, four (11%) involved aortic stent-grafts, and 33 (89%) occurred on prosthetic grafts. Among those, seven patients presented with aorto-enteric fistula.

The mean interval from the aortic graft placement to the diagnosis of aortic infection was 49.3 months (range 0.34–324.0 months).

The preoperative characteristics and clinical presentation of the patients are listed in Table 1.

Allograft reconstruction was performed as an emergency procedure in 12 patients (22%) because of ruptured mycotic aneurysm ($n = 4$); acute bleeding ($n = 4$), including three gastrointestinal bleeds through the aorto-enteric fistula; acute limb ischemia ($n = 2$); and painful mycotic aneurysm ($n = 2$). In two patients presenting with mycotic aneurysm rupture, initial urgent endovascular exclusion was performed, and then allograft reconstruction was planned. The remaining 42 patients underwent elective surgery (78%).

Operative details

A retroperitoneal approach was used in 17 patients and a transperitoneal approach was used in 34 patients. A posterolateral thoracotomy was performed in two patients, and a bilateral subcostal approach in one. Complete removal of the infected tissues was possible in 89% of patients. Suprarenal cross-clamping was performed in 21 cases (39%), including eight (15%) supraceliac clamp localizations.

Allograft reconstruction types were distributed as follows: aorto-aortic ($n = 10$), aorto-aortic with visceral and renal artery reimplantation ($n = 4$), aorto-bi-iliac ($n = 11$), aorto-bifemoral ($n = 21$), aorto-unifemoral ($n = 6$), and aorto-uniiliac ($n = 2$).

Thirty-three patients (61%) received grafts that had been preserved at −80 °C, while 21 (39%) received grafts that were treated and preserved at −150 °C according to the classic protocol.

Bacteriological cultures of intraoperative samples were positive in 33 patients. The incriminating microorganisms are shown in Table 2.

Intraoperative complications and their management are reported in Table 3.

Table 1. Patient characteristics and clinical presentation.

Preoperative characteristics	Patients, *n* (%)
Coronary artery disease/CABG/stenting/ MI >6 months	14 (27)
Congestive heart failure/MI <6 months	3 (6)
Arterial hypertension	38 (72)
COPD	5 (9)
Diabetes mellitus	12 (23)
Hypercholesterolemia	22 (42)
Chronic kidney disease[a]	9 (17)
Renal failure under hemofiltration	5 (9)
Previous stroke	3 (6)
Smoking	25 (48)
Previous abdominal operation	23 (43)
Clinical presentation	
Patients with mycotic aneurysm	17 (31)
Rupture	6 (11)
Abdominal pain	6 (11)
Thoracic pain	2 (4)
Limb ischemia	1 (2)
Infectious syndrome	2 (4)
Patients with infected aortic prosthetic graft/stent-graft	33 (61)/4 (7)
Infectious syndrome	10 (19)
Groin abscess	19 (35)
Acute limb ischemia	3 (6)
Acute gastroduodenal bleeding	3 (6)
Acute abdominal pain	2 (4)
Aortoenteric fistula	7 (13)

Note. CABG = coronary artery bypass graft; MI = myocardial infarction; COPD = chronic obstructive pulmonary disease.

[a] Chronic kidney disease, serum creatinine clearance <60 mL/min.

The early postoperative course

The early mortality rate (i.e., prior to day 30) was 28%. Two patients had suffered from native aortic infection. The 13 other early dying patients were from the group who had prosthetic graft infection (10 prosthetic grafts, three stent-grafts), including four patients with aortoenteric fistulae.

Causes of early mortality were acute bleeding in four patients (one digestive bleeding, two anastomotic disruptions, one intraoperative bleeding), multi-organ failure in four (including three ischemic colitis), acute respiratory distress syndrome in two, septic shock in two, and cardiac failure and pulmonary embolism in one patient each. One patient died suddenly after transfer to the referring hospital, without clear etiology.

Significant early postoperative complications occurred in 28 (52%) patients (Table 4). In 10 (19%) patients the

Table 2. Microorganisms from intraoperative sample culture. Polymicrobial intestinal spectrum bacteria ($n = 6$) are excluded.

Microorganism	*n* (%)
Staphylococcus aureus	13 (3 MRSA) (39.4)
Escherichia coli	4 (12.1)
Pseudomonas aeruginosa	3 (9)
Candida albicans	2 (6)
Coagulase-negative *Staphylococcus*	2 (6)
Campylobacter jejuni	1 (3)
Group B Streptococcus	1 (3)
Staphylococcus warneri	1 (3)
Klebsiella pneumoniae	1 (3)
Citrobacter koseri	1 (3)
Serratia marcescens	1 (3)
Clostridium septicum	1 (3)
Proteus mirabilis	1 (3)
Enterococcus fecalis	1 (3)
Acinetobacter baumanni	1 (3)
Klebsiella oxytoca	1 (3)

Note. MRSA = methicillin-resistant *Staphylococcus aureus*.

Table 3. Management and outcome of intraoperative complications.

Intraoperative complications	*n* (%)	Intraoperative management	Immediate outcome	Early and mid-term follow-up
Vena cava/iliac vein wound	3 (5.5)	Direct suture	Successful	One redo at day 5 for hemostasis
Infrainguinal thrombosis	3 (5.5)	Thrombectomy + in situ fibrinolysis	Successful	Patent vessels One infection recurrence (on pre-existing bypass)
Allograft leg/anastomotic occlusion	3 (5.5)	Thrombectomy ($n = 2$) Stenting ($n = 1$)	Successful	Patent vessel
Intestinal erosion	1 (1.8)	Direct suture of serous membrane	Successful	No complication
Ureteral wound	1 (1.8)	Double J catheter	Successful	No complication
Acute bleeding	1 (1.8)	Hemostatic maneuvres	Failure	Intraoperative death/ acute myocardial infarct

complication was directly related to the graft (two anastomotic disruptions, four allograft body disruptions, three allograft leg/branch thromboses and one allograft leg dissection). Four of these patients died from causes directly related to the graft, bringing the graft-related mortality rate to 7%. Nineteen (35%) patients required 34 urgent reoperations: seven intestinal resections, 14 hemostasis maneuvers, 10 revascularization procedures, one nephrectomy, one vena cava thrombectomy, and one thoracic endograft placement.

One amputation was performed during the first postoperative month, and none during the follow-up period. Thus, the limb salvage rate was 97%.

Early and late graft patency rate

There were six early allograft occlusions, always occurring on branches (iliac limbs, renal bypass).

Table 4. Early postoperative complications (prior to day 30).

Early postoperative complications	Patients, *n* (%)
Acute bleeding	11 (20)
Hemorrhagic shock	6
Retroperitoneal bleeding necessitating revision surgery	4
Anastomotic/allograft disruption	6
Anastomotic pseudoaneurysm	1
Ischemic events	13 (24)
Ischemic colitis with bowel resection	6
Lower limb by allograft segmental occlusion	4
Non-graft related lower limb ischemia	2
Renal ischemia by allograft bypass thrombosis	1
Cardiac events	4 (7)
Acute coronary syndrome	3
Arrhythmia	1
Pulmonary events	8 (15)
Acute respiratory failure	6
Pulmonary embolism	2
Deep vein thrombosis	2
Acute renal failure	3
Paraplegia	1
Persistent infection	3
Multi-organ failure	3

Among the patients who survived the early postoperative period, two (5%) suffered from allograft branch occlusion leading to additional bypass at 6 months in one case, and medical management in the second case.

Reinfection rate

Two patients developed obvious signs of reinfection at days 45 and 63 respectively. Both presented with aortic pseudoaneurysm around the proximal anastomosis with signs of systemic infection. The first patient died from acute respiratory distress syndrome before reoperation could be performed. The second patient had an aortoenteric fistula. The reintervention consisted of an extra-anatomic bypass, but the patient died from severe coagulation disorders.

Late outcomes

Three patients died at days 33, 45, and 70, respectively, before discharge, bringing the in-hospital mortality rate to 33%.

Three patients died during the follow-up period, after discharge, in postoperative months 2, 10, and 33, respectively. The first death was related to treatment, with an outbreak of new aortic pseudoaneurysm, as described above. The two remaining deaths were not related to treatment.

The overall mortality rate in the mycotic aneurysm group was 18%, while it reached 49% in the prosthetic infection group, including the seven patients who presented with aortoenteric fistulae, five of whom died during hospitalization.

No late degenerative change of the allograft was observed during follow-up.

Survival analysis

The median follow-up period for surviving patients was 12.1 months (range 0.4–83.6 months). The mean follow-up was 19.8 months. The overall mortality rate was 39% (21 of 54 patients). The rate of mortality or postoperative complications over the study period was 55% (31 patients), with a median overall and complication-free survival of 1.5 months (95% CI 0.9–9.4).

Kaplan–Meier survival curves for overall survival and event-free survival are shown in Fig. 1.

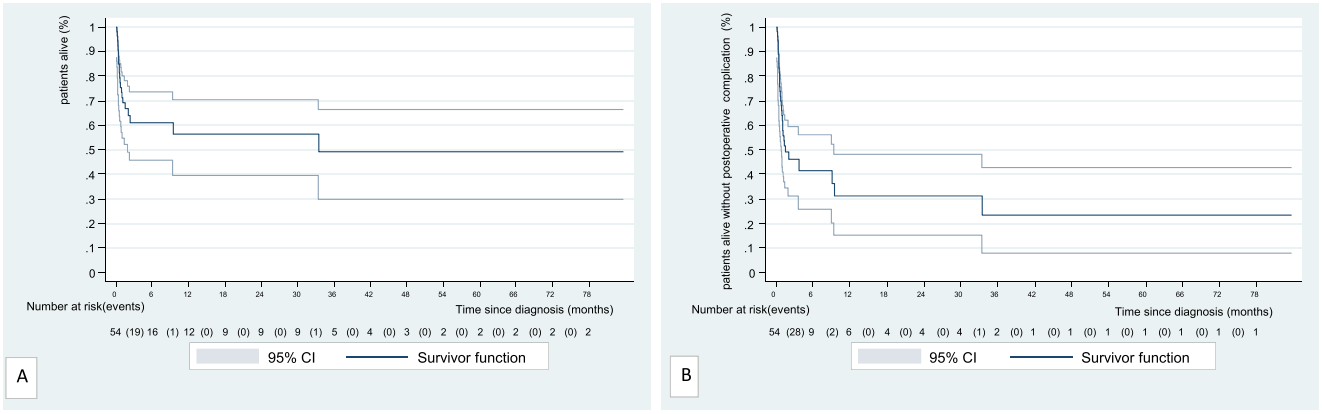

Figure 1. Kaplan—Meier survival estimate. (A) Overall survival. (B) Overall and complication-free survival. *Note*. CI = confidence interval.

Prognostic factors for mortality (overall survival analysis)

Univariate analysis identified eight factors significantly associated with postoperative mortality: age >65 years, arterial hypertension, coronary disease, chronic renal insufficiency, urgent procedures, early revision surgery, prosthetic infection, and the presence of aorto-enteric fistulae (Table 5). Multivariate analysis demonstrated that age (HR 4.4, 95% CI 1.8—10.8), chronic renal disease (HR 10.9, 95% CI 2.4—48.9), prosthetic infection (HR 6.6, 95% CI 1.3—32.7), urgent procedures (HR 5.2, 95% CI 1.2—23.3), and coronary disease (HR 3.9, 95% CI 1.0—14.5) were independently related to mortality. Early revision surgery was not entered into the multivariate analysis, being an intermediate factor between the initial intervention and the outcome. Furthermore, when all predictors are present, the 30-day survival rate would fall to 0%. When combining the most frequently encountered predictors according to our patients' characteristics, a 65-year-old man with coronary disease and elective reconstruction of prosthetic infection had a predicted 30-day survival rate of 88%.

Prognostic factors for postoperative complication or mortality (event-free survival)

Univariate analysis identified five factors associated with mortality or postoperative complication: age, diabetes, chronic kidney disease, early revision surgery, and, age of

Table 5. Clinical factors associated with all-causes death and with postoperative complications or all-causes death: overall and event-free survival analysis.

Clinical factors	Overall, $n = 54$ patients (%)[a]	Event: all-causes death				Event: postoperative complications or all-causes death			
		Unadjusted HR (95% CI)	p[b]	Adjusted HR (95% CI)	p[c]	Unadjusted HR (95% CI)	p[b]	Adjusted HR (95% CI)	p[c]
Age (years)	66.2 (±10.2)	3.6 (1.7—7.4)[e]	.00	4.4[e] (1.8—10.8)	.00	2.4[e] (1.5—4.0)	.00	2.8[e] (1.6—4.9)	.00
Sex (male)	45 (83)	1.1 (0.3—5.0)	.88			0.8 (0.3—2.4)	.68		
High blood pressure	38 (72)	5.4 (0.7—41.4)	.07			2.0 (0.7—5.8)	.22		
Dyslipidemia	22 (42)	0.8 (0.3—2.4)	.68			0.7 (0.3—1.6)	.36		
Diabetes	12 (23)	0.5 (0.1—2.3)	.36			0.4 (0.1—1.5)	.16		
Smoking	25 (48)	0.6 (0.2—1.8)	.35			0.8 (0.3—1.9)	.61		
Coronary disease	14 (27)	2.2 (0.8—6.3)	.14	3.9 (1.0—14.5)	.04	1.3 (0.5—3.1)	.59		
Chronic kidney disease	9 (17)	2.7 (0.9—8.0)	.07	10.9 (2.4—48.9)	.00	2.0 (0.7—5.1)	.17	3.4 (1.2—9.6)	.02
Emergency treatment	11 (21)	2.4 (0.8—7.2)	.11	5.2 (1.2—23.3)	.03	1.5 (0.6—3.7)	.44		
Prosthesis or endoprosthesis infection	37 (69)	3.4 (0.8—15.4)	.11	6.6 (1.3—32.7)	.02	1.4 (0.6—3.5)	.43		
Aorto-enteric fistulae	7 (14)	3.7 (1.0—14.1)	.04			2.0 (0.6—6.9)	.28		
Suprarenal aortic clamping	20 (38)	1.4 (0.5—3.9)	.57			1.7 (0.7—3.8)	.23		
Graft age (mo)[d]	6 (3; 15)	1.0 (0.98—1.03)	.50			1.0 (1.00—1.03)	.05		
Cryopreservation protocol: −80 °C	33 (61)	1.4 (0.4—4.9)	.65			1.1 (0.4—3.3)	.87		
Operating time (h)	5 (4; 7)	0.9 (0.6—1.3)	.49			0.9 (0.6—1.2)	.42		
Early revision surgery	10 (19)	4.2 (1.4—12.5)	.01			3.7 (1.6—8.6)	.00		

[a] *n* (%), mean (±SD) or median (Q1; Q3).
[b] Log rank test.
[c] Cox regression.
[d] Time from preservation to implantation.
[e] Per 10 years.

allograft. Multivariate analysis identified age (HR 2.8, 95% CI 1.6–4.9) and chronic kidney disease (HR 3.4, 95% CI 1.2–9.6), as independent predictors of postoperative death or complication.

Neither allograft age nor cryopreservation protocol were independent prognostic factors in the multivariate analysis. The presence of an aortoenteric fistula appears to be correlated with early death only in univariate analysis ($p = .04$). In particular, stent-graft infection was not correlated with a negative outcome ($p = .23$). The relationship between cryopreservation protocol and the occurrence of graft-related complications was tested: two (18%) patients who received the −150 °C protocol and six (18%) patients who received the −80 °C protocol developed a graft-related complication. The difference was not significant (Fisher's test p-value = 1.0).

DISCUSSION

Many therapeutic options address aortic infections. On account of considerable early mortality (up to 27%[7,8]) and issues such as bypass infection (8–27%[7–9]), and aortic stump or prosthetic rupture (9–15%), extra-anatomical bypass is no longer considered the treatment of choice. Any alternative technique, especially in situ reconstruction, is supposed to achieve a better mortality, patency, and reinfection rate.

The expected benefits of cryopreserved allografts are numerous: better applicability than autologous tissues, shortening of the duration and magnitude of the intervention when harvesting veins, and a reduction in the reinfection rate. This study highlights the following:

- a high early mortality and graft-related complication rate;
- the significant predictive value of age, impaired renal function, coronary disease, urgent procedure, and prosthetic infections;
- the equivalent early behavior of allografts, whether preserved at −80 °C or after controlled-rate freezing at −150 °C, independently of the graft age.

Mortality

In this series, early postoperative mortality reaches 28%. This value is greater than reported in series published during the last decade where mortality ranges from 18% to 22%;[6,9–11] in the experience of Bisdas et al., it even falls to 9%.[12] The characteristics of the patients in this study are comparable with those included in the other studies discussed. In this study, the suprarenal clamping rate reached 39%, which is comparable with the series of Kieffer et al. (38%),[6] without it being a significant risk factor of mortality. The bacteriological data obtained in this study are close to the spectrum generally reported, with a predominance of *Staphylococcus aureus* (34.4%). When this series is compared with the study reported by Bisdas et al.,[12] which had a similar number and type of patients, and a significantly lower early mortality rate, a few differences should be highlighted: homografts were stored in the vapor phase of liquid nitrogen and were impregnated with neomycin, and only 20% of mycotic aneurysms were ruptured at presentation.

A previous study, performed when the regular use of cryopreserved arterial allografts began, reported a 30-day mortality rate of 22%.

Early and late graft-related complications

In 10 patients (19%), early complications were related to the graft (rupture, thrombosis, dissection). Non-anastomotic mid-graft rupture occurred in four patients with high-risk infections (two aorto-enteric fistulae, two infections with Gram-negative bacteria) and were seemingly related to a local virulent infectious process. That cryopreservation induces allograft fragility is another hypothesis. In the series by Noel et al.,[10] 26% of patients had allograft-related early complications. This rate falls to 7% and even 0% in other series.[12,13] Among the 179 patients reported by Kieffer et al.,[6] 36 underwent 42 (20%) revisions, of which eight (19%) were related to the use of allografts, the majority being fresh allografts. The high rate of early graft-related complications seen in the study appears to be the main impediment to the utilization of cryopreserved allografts. The historical impediment to the use of allografts has been the late degenerative change and is actually curbed by the abandonment of the use of fresh allografts and the avoidance of thoracic segments, both of which are prognostic factors for late events.[6] Such lesions can generally be addressed by minimally invasive endovascular procedures.[14] Their rate of occurrence is low, ranging from 0% to 10%,[9,12–14] but caution is still required because longer follow-up is needed. In this report there were two graft occlusions and no graft dilations.

Alternative reconstruction material

During the study period, the policy was to perform systematic in situ allograft replacement, the tissue bank being part of the Henri Mondor University Hospital. Thus, there were few reconstructions using alternative materials or first-intention extra-anatomical bypass.

In the series of Batt et al.,[15] silver-coated graft usage is associated with a perioperative mortality of 17%, while it decreased to 7% among the 27 patients studied by Pupka et al.[16] In both reports, the number of revision procedures is not explicit.

As for rifampicin-soaked grafts, Oderich et al.[7] reported an early mortality rate of only 8%, without further mention of the reintervention rate. Ehsan and Gibbons,[17] who used autologous veins, report a mortality rate of 5% for aortic reconstructions ($n = 16$) and extra-aortic reconstructions. However, venous reconstruction is unsuitable for the emergent situation.[18] Interestingly, O'Connor et al.[19] calculated the combined mean rate of adverse events (mortality, amputation, reinfection). The event rate was 0.16 for extra-anatomical bypass, 0.07 for rifampicin-coated

prosthesis, 0.09 for cryopreserved allografts, and 0.10 for veins.[19]

Cryopreservation method

Two cryopreservation protocols (−80 °C and −150 °C) were used. All allografts that had been cryopreserved at −150 °C were either harvested before 2002 or imported from other tissue banks that used this protocol, with no expiration date. Starting from 2002, all grafts preserved at the tissue bank of the Henri Mondor University Hospital were stored at −80 °C. The use of a −80 °C freezing protocol was supported by the occurrence of allograft fractures after cryopreservation using nitrogen vapor at −150 °C[20–22] and lesions of extracellular matrix during manipulations in cold nitrogen.[23] In addition, graft preservation at −80 °C resulted in no difference in the structural or mechanical properties of rabbit carotids.[24] In clinical terms, Castier et al.[25] used human allografts preserved at −80 °C in peripheral reconstructions, and did not report any allograft thrombosis or disruption with a mean follow-up of 34 months. In the series 61% of patients received grafts that had been cryopreserved at −80 °C. The cryopreservation protocol did not have a significant influence on early mortality ($p = .76$) or postoperative complication rate ($p = .87$) The relationship between cryopreservation method and the occurrence of graft rupture or thrombosis was tested, and no difference was found between the protocols. This relationship could not be reliably assessed, as the study of factors associated with graft-related complications was affected by the fact that early mortality might have prevented the detection of these complications. Knowing that grafts preserved at −80 °C were meant to be used within 2 years, we studied the duration of cryopreservation and found that grafts stored at −80 °C were most frequently used within 6 months, as median graft age at use was 4.7 months; however, it was 18.5 months for the allografts kept at −150 °C. After performing statistical analysis, the age of allograft was found to be a predictive factor in the univariate analysis for the occurrence of death or postoperative complications.

CONCLUSION

Unsatisfactory results for the use of cryopreserved allografts during in situ reconstruction of infected aortic aneurysms or grafts were observed. These results are difficult to interpret when compared with other series of similar populations and clinical and procedural data. The main obstacle appears to be the rate of early graft-related complications. The reinfection and limb salvage rates were satisfactory. Age, chronic renal disease, coronary disease, prosthetic infections, and urgent procedures were independent prognostic factors for postoperative mortality.

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CONFLICT OF INTEREST

None.

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