ELSEVIER

Clinical Research

Juxtarenal Abdominal Aortic Aneurysm: Results of Open Surgery in an Academic Center

Obren D. Drazic, Cristian F. Zárate, José F. Valdés, Albrecht H. Krämer, Michel P. Bergoeing, Leopoldo A. Mariné, José F. Vargas, and Renato A. Mertens, Santiago, Chile

Background: The objective of the study is to report our experience with conventional surgery for juxtarenal abdominal aortic aneurysms (JRAs) by evaluating incidence of acute renal failure and perioperative mortality. Secondary objectives are to evaluate general morbidity and the need for permanent postoperative dialysis and to assess the influence on long-term survival of preoperative risk factors and deterioration of perioperative renal function.
Methods: A retrospective cohort study of 110 patients with JRA electively treated by open surgery between March 1992 and March 2018 was made. Data were obtained from clinical records, describing demographics, perioperative variables, and results. Acute kidney injury (AKI) was defined as 50% decrease in glomerular filtration rate or two-fold increase in serum creatinine. Multivariate analysis was performed by logistic regression to establish risk factors for renal failure. The influence of preoperative risk factors and deterioration of perioperative renal function on long-term survival was studied using Cox regression model. Descriptive and inferential statistics were used in the analysis.
Results: 110 consecutive patients were treated with an average age of 71 years, 82.7% male; 81% hypertensive and 41% active smokers. 46.3% had stage III or higher preoperative chronic kidney disease. Median diameter of the aneurysm was 5.7 cm. Interruption of bilateral renal flow was required in 73 patients (66.4%) and unilateral in 37 (33.6%). The average renal clamping time was 34.5 min. AKI occurred in 9 patients (8.2%). Two patients (1.8%) required postoperative dialysis, one of them permanent. Median hospital stay was 7 days. Thirty-three patients (30%) had at least one complication. Postoperative mortality was 2.7% (3 patients), two of them developed AKI. Multivariate analysis established a longer operative time and need for renal revascularization as independent risk factors for AKI. In the survival analysis, age, cerebrovascular disease, chronic obstructive pulmonary disease, and perioperative AKI were identified as risk factors for long-term mortality.
Conclusions: JRA open surgical repair can be performed with low morbidity and mortality. Although transient acute renal dysfunction may be relatively frequent, the need for hemodialysis is low. Our study is a reference point to compare with endovascular repair.

INTRODUCTION

A juxtarenal abdominal aortic aneurysm (JRA) is defined as an aortic dilatation immediately below the ostium of the lowest renal artery and corresponds to 15% of all abdominal aortic aneurysms (AAAs).[1] Compared to infrarenal AAA, JRA repair is associated with greater morbidity and mortality because of a greater anatomic exposure and, by definition, a variable period of renal ischemia. To avoid

The authors have no conflict of interest to declare.

Departamento de Cirugía Vascular y Endovascular, Escuela de Medicina, Pontificia Universidad Católica de Chile, Santiago, Chile.

Correspondence to: Renato A. Mertens, MD, FACS, Departamento de Cirugía Vascular y Endovascular, Escuela de Medicina, Pontificia Universidad Católica de Chile, Diagonal Paraguay 362, Office 326, Santiago, Chile; E-mail: renatomertens@gmail.com

Ann Vasc Surg 2019; ■: 1–7
https://doi.org/10.1016/j.avsg.2019.10.036

Manuscript received: August 5, 2019; manuscript accepted: October 1, 2019; published online: ■ ■ ■

both the exposure and renal ischemia, endovascular techniques have been developed to extend the stent graft proximally to reach an adequate seal adding fenestrations or branches to maintain renal perfusion at all times, although 30–40% of patients are not amenable for these devices.[2] The addition of higher cost, limited availability, and the fact that long-term results are still under evaluation keep open surgery as a viable option for these patients.

Although we started an aortic endovascular program on 1997, the high cost of custom-made devices and the lack of coverage by insurance companies have been major problems to include these procedures as a relevant option in our practice for JRA repair, except for patients included in clinical research trials.[3] Open surgery remains the first option at our institution. In fact, the number of open repairs did not vary significantly after we started our experience with fenestrated endografts in 2009.

The purpose of this study is to evaluate our experience in open JRA repair during a 26-year period, emphasizing evaluation of renal morbidity and perioperative and late mortality, seeking to define a valid comparison standard with currently and future available endovascular procedures.

MATERIAL AND METHODS

A retrospective cohort study with intentional sampling was set up, including all AAA elective patients operated on consecutively with proximal clamping below the superior mesenteric and at least above one renal artery, between March 1992 and March 2018 by our department members. The extent of the aneurysm was defined by computed tomography and intraoperative findings. Nonelective surgery, patients treated with endografting, and those with major anatomical variations (horseshoe kidney or anomalous origin of the renal arteries) were excluded. Approval from the institutional ethics committee was obtained. Data were collected from clinical records, operative notes, death certificates, and contact with the patient, family members, or referring physician.

Demographic Variables

Gender, age, and comorbidities were identified. Coronary artery disease was defined as history of acute myocardial infarction, positive stress test, or previous coronary revascularization. Chronic obstructive pulmonary disease (COPD) was defined as need of bronchodilator therapy or an abnormal pulmonary function test. Cerebrovascular disease was defined as history of stroke, transient ischemic attack, or previous carotid endarterectomy or stenting.

Operative Factors

Patients were operated by transperitoneal or retroperitoneal approach. All patients received intravenous heparin before aortic clamping. Operative and anesthesia notes were reviewed. Data were obtained about position of the clamp, total surgical time, renal ischemia time, transitory or definitive division of the left renal vein, additional renal artery procedures (reimplantation, endarterectomy or bypass), type of aortic graft, estimated blood loss, number of packed red blood cells units transfused, and infusion of cold preservation solution (normal saline 400 cc, mannitol 100 cc, hydrocortisone 500 mg, and 2500 IU of unfractionated heparin) into the renal arteries during clamping.

Any additional surgical procedure was recorded.

Postoperative Evolution

Perioperative mortality was defined as in-hospital death or within 30 postoperative days. We recorded postoperative length of stay, need for vasoactive drugs, early reoperation (same admission or within 30 days), nonrenal morbidity, and long-term need for reoperation and survival.

Definition and Analysis of Renal Function

Renal function was estimated according to the Cockcroft-Gault formula.[4] Patients with a glomerular filtration rate (GFR) lower than 60 ml/min were considered as chronic kidney disease (CKD). All patients were classified according to the Kidney Disease Outcomes Quality Initiative[5] and stratified as normal (stages I and II with GFR greater than 60 ml/min) and abnormal (stage III or IV with GFR less than 60 ml/min).

Renal morbidity was evaluated according to RIFLE criteria,[6] defining acute kidney injury (AKI) as a two-fold increase in serum creatinine or a greater than 50% decrease in GFR. Need for in-hospital, permanent at discharge, or late onset of dialysis was recorded.

Statistical Analysis

Continuous variables are presented as mean ± standard deviation or median (range). Categorical variables are presented as frequency.

Univariate analysis of possible risk factors was performed with X^2 for categorical variables and *t*-test for continuous variables when they had normal

Table I. Demographic characteristics

Variables	
Total number of patients	110
Age, average, range	70.6 (50–87)
Male, *n* (%)	91 (82.7%)
Hypertension, *n* (%)	89 (80.9%)
Dyslipidemia, *n* (%)	48 (43.6%)
Diabetes, *n* (%)	11 (10%)
Smoking, *n* (%)	87 (79%)
Current smoking, *n* (%)	45 (40.9%)
Coronary disease, *n* (%)	37 (33.6%)
COPD, *n* (%)	5 (4.6%)
Cerebrovascular disease, *n* (%)	16 (14.6%)
CKD stage III or more, *n* (%)	50 (46.3%)
CKD stage IV or more, *n* (%)	8 (7.3%)
Preoperative serum creatinine, average	1.22 mg%
Preoperative GFR, average	66.4 mL/min
Aneurysm size, median (range)	5.7 cm (3.3–12)

distribution. The Mann–Whitney *U* test was used when those criteria were not met. Multivariate analysis was performed using logistic regression with forward stepwise selection to identify acute renal failure predictors.

A survival analysis was performed using Kaplan-Meier curves. Cox regression model was used to calculate the effect of the variables on long-term survival. The proportionality of the variables introduced in the analysis was checked both graphically and by the introduction of the interaction between the main variable and the time-dependent covariate. Those variables whose *P* was less than 0.05 in the univariate analysis were introduced in the multivariate analysis.

All statistical tests were two-tailed, with significance established at $P < 0.05$. Stata 14.1 software was used (StataCorp, College Station, TX).

RESULTS

Between March 1992 and March 2018, 1,355 patients were consecutively treated for AAA at our center by open or endovascular approach, of which 110 (8.1%) were JRA treated by open surgery. The population characteristics are detailed in Table I. During the same period, 14 patients were treated with fenestrated endografts, 12 normal-risk patients for patient choice or as part of a research protocol,[3] and 2 high-risk patients not considered for open repair.

Preoperative Variables

Median size of the aneurysm was 5.7 cm (3.3–12 cm), a patient with a 33 mm aneurysm was operated on because of recurrent lower extremity atheroembolism. Average age was 70.6 years (50–87 years), 82.7% male. Most patients had hypertension (80.9%), a third had coronary artery disease (33.6%). 46.3% of the patients had CKD (GFR less than 60 mL/hr).

Table II. Operative variables

Surgical approach	
Transperitoneal, *n* (%)	103 (93.6%)
Retroperitoneal, *n* (%)	5 (4.5%)
Thoracofrenolaparotomy, *n* (%)	2 (1.8%)
Operative time minutes, median, (range)	215 (90–540)
Renal clamping time minutes, average (range)	34.5 ± 23 (4–130)
Prosthesis	
Tubular, *n* (%)	43 (39.1%)
Bifurcated, *n* (%)	67 (60.9%)
Associated procedures to renal arteries, *n* (%)	25 (22.7%)
Endarterectomy	1
Reimplantation	17
Aorto-renal bypass	7
Intraoperative fluids	
Estimated blood loss, Liters, median	1 (0.05–5.5)
Blood products transfusion, Liters, median	0.3 (0–3.7)
Water balance, Liters, median	2 (0.3–6.5)
Renal preservation solution use, *n* (%)	30 (27.3%)
Left renal vein division, *n* (%)	13 (11.8%)
With reanastomosis	5
Without reanastomosis	8

Operative Variables

Operative variables are detailed in Table II. The most frequent approach was transperitoneal (93.6%). Two cases were approached by low thoracophrenolaparotomy because of high origin of the renal arteries; one of these patients presented with an inflammatory aneurysm and a prior frustrated attempt of transperitoneal repair elsewhere, which resulted in intestinal perforation and peritonitis.

Median surgical time was 215 min, with an average renal artery cross-clamping time of 34.5 min, bilateral in 73 patients (66.4%), and unilateral in 37 (33,6%); cold preservation solution was used in 30 patients (27.3%) according to surgeon's preference. In 25 (22.7%) patients, an additional procedure was performed in one or both renal arteries, which required a longer renal ischemia time (mean difference: 25.1 min, CI: 15.9–34.4,

Table III. Postoperative results

Postoperative hospital stay, days, median (range)	7 (4–50)
Mechanical ventilation need, *n* (%)	12 (10.9%)
ICU stay, days, median (range)	3 (1–39)
Vasoactive drugs need, *n* (%)	30 (27.3%)
Reoperation, n	7
Early (<30 days), *n* (%)	6 (5.5%)
Late (7 years), *n* (%)	1 (0.9%)
Follow-up, months	79 (0–197)
Mortality, *n*	43
Perioperative, *n* (%)	3 (2.7%)
Late, *n* (%)	40 (36.4%)
Morbidity, *n* (%)	33 (30%)

$P < 0.0001$). The left renal vein was divided to increase exposure according to surgeon's preference in 13 patients, being reanastomosed in 5 also depending on surgeon's preference. Fifty patients (45.5%) did not require transfusion of blood products.

Postoperative Results

Median postoperative hospital stay was 7 days (4–50) and median ICU stay was 3 days (range, 1–39). Other postoperative results are detailed in Table III. Operative mortality was 2.7% (3 patients); one of them due to pulmonary thromboembolism after discharge, despite receiving enoxaparin prophylaxis during hospitalization, and two due to colonic necrosis with subsequent sepsis and refractory shock. Both had preserved hypogastric circulation, and in one, the inferior mesenteric artery was reimplanted.

Perioperative morbidity (Table IV) was 30% (33 patients), the most frequent complication was postoperative AKI, which occurred in 9 patients (8.2%). In 5 of those patients (55.6%), a separate procedure was performed to the renal arteries. No patient with preoperative GFR greater than 90 ml/min presented AKI. Two patients (1.8%) required dialysis, one of them permanent. This patient had previous stage IV CKD with serum creatinine of 2.4 mg% (GFR: 21.2 mL/min). The other patient expired because of intestinal ischemia.

Four patients presented intestinal or colonic ischemia (diagnosed by CT imaging or endoscopy), one of which required resection of the distal ileum and right colon, the other 3 were handled with support therapy; 2 of these 4 patients died of sepsis.

Five patients (4.5%) presented in-hospital pneumonia, one of them associated with mechanical ventilation.

Table IV. Morbidity, *n* (%)

Digestive	8 (7.2%)
Ileus	3 (2.7%)
Intestinal or colonic ischemia	4 (3.6%)
LGB without obvious ischemia	1 (0.9%)
Respiratory	7 (6.3%)
ARDS	2 (1.8%)
Pneumonia	5 (4.5%)
Cardiovascular	7 (6.3%)
Arrhythmia	4 (3.6%)
Myocardial infarction	1 (0.9%)
Pulmonary embolism	1 (0.9%)
Deep venous thrombosis	1 (0.9%)
Acute kidney injury	9 (8.2%)
Need for dialysis	2/9 (1.8%)
Surgical	5 (4.5%)
Operative wound infection	2 (1.8%)
Inguinal lymphocele[a]	1 (0.9%)
Intra-abdominal bleeding	2 (1.8%)

LGB, lower gastrointestinal bleeding; ARDS, acute respiratory distress syndrome.
[a]Patient undergoing aorto-bifemoral bypass repair.

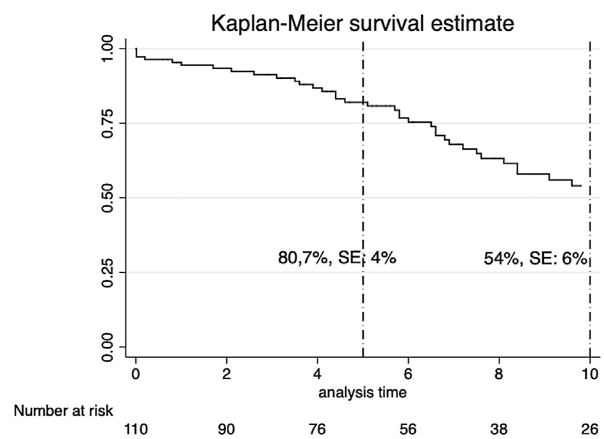

Fig. 1. Survival analysis with Kaplan Meier curve.

Long-term Results

Average follow-up was 79 months (range, 0–197). Average survival was 70.3 months (range, 0.1–197). 40 patients died during follow-up, 5 of them because of complications of thoracic aortic disease, either aneurysm or dissection. Survival was 80.7% at 5 years and 54% at 10 years (Fig. 1).

Eight patients had impairment of renal function during follow-up and 5 required dialysis (1, 2, 5, 8, and 12 years after surgery). Preoperative renal function was normal in only 2 of these patients.

During follow-up, eleven patients (10%) required additional vascular interventions, mainly aneurysms in other territories or atherosclerotic

Table V. Univariate analysis for acute kidney injury

Variable	*P*
Age	0.9277
Gender	0.703
Weight	0.1295
Hypertension	0.124
Diabetes	0.924
Dyslipidemia	0.178
Coronary artery disease	0.126
Cerebrovascular disease	0.191
Preoperative GFR	0.8284
Preoperative serum creatinine	0.824
ASA	0.76
Aneurysm diameter	0.1062
Independent renal artery procedure[a]	**0.012**
Renal preservation solution use	0.214
Bilateral renal clamping	0.14
Operative time[a]	**0.0046**
Renal clamping time	0.2695
Blood loss	0.5904

$P < 0.05$ highlighted in bold.
ASA, American Society of Anesthesiologists physical status classification.
[a]Statistically significant factors.

disease of the lower extremities. One patient presented infection of the aortic graft and aortoduodenal fistula 7 years after the original surgery; an axillobifemoral bypass was performed followed by hepatic to right renal artery bypass, ligation of the aorta with preservation of the left renal artery, and graft removal. He is alive and with stable renal function 8 years after the original surgery.

Risk Analysis for AKI

Univariate analysis identifying risk factors of AKI found that either longer operative time or need for additional procedures on the renal arteries were related to development of AKI (Table V).

Multivariate analysis confirmed that longer operative time and performing an extra procedure on the renal arteries were independent variables in the development of AKI (Table VI), with odds ratio of 1.009 and 4.818, respectively. Previous renal function (as serum creatinine or preoperative GFR), renal ischemia time, or division of the left renal vein were not independent factors for development of this complication.

Survival Analysis

In the univariate analysis, the significant variables were age, congestive heart failure (CHF), cerebrovascular disease, COPD, aneurysm size, acute renal failure, and number of days in the ICU. As a result, age (hazard ratio: 1.06, 95% CI: 1.006−1.12), cerebrovascular disease (hazard ratio: 2.55, 95% CI: 1.10−5.87), COPD (hazard ratio: 3.82, 95% CI: 1.38−10.58) and perioperative AKI (hazard ratio: 4, 95% CI: 1.39−11.48) were identified as risk factors for reduced long-term survival (Table VII).

Table VI. Multivariate analysis for AKI

Variable	OR	*P*	CI 95%
Operative time	1.009	0.019	1.001−1.016
Renal artery procedure	4.818	0.036	1.108−20.950

OR, odds ratio.

DISCUSSION

We report 110 patients with JRA treated by open surgery and followed for 79 months. These are more challenging cases than infrarenal AAAs, with higher morbidity and mortality due to more extensive surgical exposure, longer surgical time, and renal ischemia.

Mortality has decreased since the initial series published by Crawford and is currently reported as less than 5% in large volume centers.[7] It is interesting to note that our 2.7% mortality covers a broad period of 26 years. During that period, the use of fenestrated devices has been unusual, being open repair our first choice for JRA treatment. It is also remarkable that the 80.7% 5-year survival in this population of 71-year-old high-risk patients is similar to the 5-year survival of 85.4% for the general population in Chile in the age range of 70−74 years,[8] confirming safety and durability of the reconstruction.

Postoperative AKI incidence was the most frequent complication in our series, but only occurred in patients with preoperative GFR less than 90 ml/min and with a relatively low incidence (8.2%) compared with the available literature; only 2 of these patients required dialysis, one of them with significant prior renal dysfunction required permanent dialysis (0.9%). In a systematic review of postoperative renal failure in 1,256 patients from 21 reports between 1986 and 2008,[1] the rate of AKI varied from 0% to 39%. A fairly wide range, probably due to the heterogeneity of definitions.

In another study carried out previously at our institution in which we reviewed all AAA operated electively,[9] we found an incidence of 5.8% of postoperative AKI under the same criteria, 2 factors had a significant association: history of hypertension

Table VII. Multivariate risk analysis for long-term death

Variable	HR	*P*	95% CI
Age	1.06	0.027	1.006−1.116
CHF	4.528	0.086	0.808−25.355
Cerebrovascular disease	2.546	0.028	1.103−5.872
COPD	3.822	0.010	1.380−10.582
Aneurysm diameter	1.343	0.054	0.995−1.814
Perioperative AKI	4.001	0.010	1.394−11.484
ICU stay	1.056	0.065	0.997−1.119

and a preoperative serum creatinine greater than 1.5 mg%, but that series reported in 1992 included patients treated for infrarenal and juxtarenal aneurysms.

Transient intraoperative renal ischemia undoubtedly causes renal dysfunction, as has been demonstrated in experimental model.[10] In our case, the mean time of 34.5 min of renal ischemia was similar to those published in other series,[11−14] and it was not a significant factor in development of AKI. However, renal ischemia time was higher in the group that underwent an additional procedure on the renal arteries and that was a strong predictor of AKI.

It is also noteworthy that bilateral renal clamping was performed in 73 patients (66.4%). Eight (11%) of these patients presented AKI compared with only one patient (2.7%) in the unilateral clamping group. Despite this clear and clinically relevant difference, it did not reach statistical significance ($P = 0.14$), as shown in Table VI.

The use of cold solution as renal protection reported by Yeung et al.[15] was associated with 0% postoperative renal failure in 23 patients studied, defined as an increase in serum creatinine greater than 0.5 mg/dl. In our experience, cold renal preservation solution was used in 27.3% of the cases, and based on surgeon preference, we did not find a significant protective role.

The ESVS guideline notes that there is no convincing evidence in favor of pharmacological protection of renal function in JAAA surgery, whereas cold renal perfusion may be beneficial. In addition, keeping the suprarenal clamp as short as possible (<25 min) is crucial to reduce ischemic damage to the kidney.[16]

Division of the left renal vein is also a factor mentioned in the literature as predictor of renal failure,[17,18] a fact that we did not confirm. One of the patients in whom the vein was not reanastomosed presented AKI, from which he recovered, presenting normal renal function in the last control.

Multivariable analysis of risk factors for AKI clearly showed that performing extra procedures on the renal arteries, as well as a longer duration of surgery, are contributing factors. Other important variables described in the literature, such as previous renal function or renal clamping time, were not statistically significant in our series,[13,14,17,19−21] maybe because the incidence of AKI was surprisingly low, which reduced the significance of such variables. There is clearly a trend in univariate analysis, which could be significant in a series with more patients that increase the power of the study. On the other hand, the length of the procedure was a significant predictor of AKI in this series. There are several reasons for an operation to be more time-consuming: technical problems during exposure, surgeon's experience, unexpected findings, and others. Obviously doing a faster procedure is not a viable option as a preventive mean, but this information can be used in the postoperative period deciding on different monitorization alternatives and more aggressive fluid management.

Although most AAAs are currently being treated with endovascular techniques,[22] the proportion of JRA treated by open surgery remains high.[18] Endovascular alternatives for the treatment of the JRA include fenestrated endografts (FEVAR) and EVAR with snorkel or chimney technique (ch-EVAR).

A systematic review of 33 studies on JRA repair between 1992 and 2012 compared 1575 cases treated by open surgery and 751 cases of FEVAR.[23] Perioperative mortality was not different. However, patients treated with FEVAR had higher reintervention rate and worse survival compared with open surgery. There was no difference in postoperative renal failure during the hospital stay, but the FEVAR group had a higher incidence of chronic renal failure at follow-up. Nevertheless, it should be considered that patients of the FEVAR group had a higher prevalence of heart failure, respiratory insufficiency, and diabetes, from which a higher surgical risk and lower long-term survival are expected, as we found in our population for patients with CHF and COPD.

Thus, FEVAR is considered a good alternative, especially for high-risk patients; there are few reports of long-term results with this technique.[23,24] Cost and availability of these endografts hamper the FEVAR technique, requiring most of the time construction of custom-made devices.

Another readily available endovascular treatment option is the use of the snorkel technique or covered stent chimney (CHIMPS: CHIMney-Periscope-Snorkel), potentially a more accessible mean with similar results to FEVAR.[25]

CONCLUSIONS

Elective open surgical repair for JRA can be performed with low morbidity and mortality. Postoperative renal failure was the most frequent complication, albeit with a low incidence compared with other series. Dialysis was very unusual.

Statistically, we were able to determine that a longer operative time or renal artery revascularization are factors that significantly affect the postoperative renal function.

Our series sets a basis for subsequent comparison with present or future endovascular procedures.

LIMITATIONS

Despite being a series with a significant number of patients, we believe that it is not enough to determine factors that could influence AKI beyond those described. In addition, our work presents the usual limitations of a nonconcurrent review.

Acknowledgments to Oslando Padilla, statistician of the statistical advisory unit of the Medical School of the Pontificia Universidad Católica de Chile.

REFERENCES

1. Jongkind V, Yeung KK, Akkersdijk GJM, et al. Juxtarenal aortic aneurysm repair. J Vasc Surg 2010;52:760−7.
2. Wilderman M, Sanchez LA. Fenestrated grafts or debranching procedures for complex abdominal aortic aneurysms. Perspect Vasc Surg Endovasc Ther 2009;21:13−8.
3. Mertens R, Bergoeing M, Mariné L, et al. Ventana fenestrated stent-graft system for endovascular repair of juxtarenal aortic aneurysms. J Endovasc Ther 2012;19:173−8.
4. Cockcroft DW, Gault H. Prediction of creatinine clearance from serum creatinine. Nephron 1976;16:31−41.
5. National Kidney Foundation AS, Coresh J, Bolton K, et al. Part 4. Definition and classification of stagesof chronic kidney disease. Am J Kidney Dis 2002;39:S46−75.
6. Lopes JA, Jorge S. The RIFLE and AKIN classifications for acute kidney injury: a critical and comprehensive review. Clin Kidney J 2013;6:8−14.
7. Tallarita T, Sobreira ML, Oderich GS. Results of open pararenal abdominal aortic aneurysm repair: Tabular review of the literature. Ann Vasc Surg 2011;25:143−9.
8. Villalón G, Sergio C, Schneider V, Carrasco F. Chile tabla de vida por método de mortalidad óptima. 1998-2013. http://historico.ine.cl/canales/menu/publicaciones/calendario_de_publicaciones/pdf/mortalidad_sept_2016.pdf
9. Mertens R, Valdés F, Kramer A. Disfunción renal precoz post cirugía electiva de la aorta infrarenal: incidencia y factores predictivos. Rev Med Chil 1992;120:1011−6.
10. Malek M, Nematbakhsh M. Renal ischemia/reperfusion injury; from pathophysiology to treatment. J Ren Inj Prev 2015;4:20−7.
11. Ockert S, Schumacher H, Böckler D, et al. Comparative early and midterm results of open juxtarenal and infrarenal aneurysm repair. Langenbecks Arch Surg 2007;392:725−30.
12. Marrocco-Trischitta MM, Melissano G, Kahlberg A, et al. Glomerular filtration rate after left renal vein division and reconstruction during infrarenal aortic aneurysm repair. J Vasc Surg 2007;45:481−6.
13. Knott AW, Kalra M, Duncan AA, et al. Open repair of juxtarenal aortic aneurysms (JAA) remains a safe option in the era of fenestrated endografts. J Vasc Surg 2008;47:695−701.
14. Sugimoto M, Takahashi N, Niimi K, et al. Long-term fate of renal function after open surgery for juxtarenal and pararenal aortic aneurysm. J Vasc Surg 2018;67:1042−50.
15. Yeung KK, Jongkind V, Coveliers HME, et al. Routine continuous cold perfusion of the kidneys during elective juxtarenal aortic aneurysm repair. Eur J Vasc Endovasc Surg 2008;35:446−51.
16. Wanhainen A, Verzini F, Van Herzeele I, et al. European Society for Vascular Surgery (ESVS) 2019 Clinical Practice Guidelines on the Management of Abdominal Aorto-iliac Artery Aneurysms. Eur J Vasc Endovasc Surg 2019;57:8−93.
17. Dubois L, Durant C, Harrington DMD, et al. Technical factors are strongest predictors of postoperative renal dysfunction after open transperitoneal juxtarenal abdominal aortic aneurysm repair. J Vasc Surg 2013;57:648−54.
18. West CA, Noel AA, Bower TC, et al. Factors affecting outcomes of open surgical repair of pararenal aortic aneurysms: a 10-year experience. J Vasc Surg 2006;43:921−7. discussion 927-8.
19. Sarac TP, Clair DG, Hertzer NR, et al. Contemporary results of juxtarenal aneurysm repair. J Vasc Surg 2002;36:1104−11.
20. Ferrante AMRR, Moscato U, Colacchio EC, et al. Results after elective open repair of pararenal abdominal aortic aneurysms. J Vasc Surg 2016;63:1443−50.
21. Deery S, Lancaster R, Baril D, et al. Contemporary outcomes of open complex abdominal aortic aneurysm repair. J Vasc Surg 2016;63:1195−200.
22. Beck AW, Sedrakyan A, Mao J, et al. Variations in abdominal aortic aneurysm care: a report from the international consortium of vascular registries. Circulation 2016;134:1948−58.
23. Rao R, Lane TRAA, Franklin IJ, et al. Open repair versus fenestrated endovascular aneurysm repair of juxtarenal aneurysms. J Vasc Surg 2015;61:242−55.
24. Di X, Ye W, Liu C-W, et al. Fenestrated endovascular repair for pararenal abdominal aortic aneurysms: a systematic review and meta-analysis. Ann Vasc Surg 2013;27:1190−200.
25. Donas KP, Lee JT, Lachat M, et al. Collected world experience about the performance of the snorkel/chimney endovascular technique in the treatment of complex aortic Pathologies. Ann Surg 2015;262:546−53.