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Does the Routine Skin-Only Closure in Ruptured Abdominal Aortic Aneurysm Repair Safely Diminish Abdominal Compartment Syndrome? A Hypothesis Generating Retrospective Study

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Abstract

Background Abdominal compartment syndrome (ACS) often complicates ruptured abdominal aortic aneurysm (rAAA) repair. We report results with routine skin-only abdominal wound closure after rAAA surgical repair.

Methods This was a single-center retrospective study including consecutive patients undergoing rAAA surgical repair for the duration of 7 years. Skin-only closure was routinely performed, and if possible, secondary abdominal closure was performed during the same admission. Demographic information, preoperative hemodynamic condition, and perioperative information (ACS, mortality, rate of abdominal closure, and postoperative outcomes) were collected.

Results During the study period, 93 rAAAs were recorded. Ten patients were too frail to undergo repair or refused treatment. Eighty-three patients underwent immediate surgical repair. The mean age was 72.4 ± 10.5 years, and the vast majority were male (82:1). Preoperative systolic blood pressure <90 mm Hg was recorded in 31 patients. Intraoperative mortality was recorded in nine cases. Overall in-hospital mortality was 34.9% (29/83). Primary fascial closure was performed in five patients, while skin-only closure was performed in 69. ACS was recorded in two cases in whom skin sutures were removed and negative pressure wound treatment was applied. Secondary fascial closure was feasible in 30 patients during the same admission. Among 37 patients not undergoing fascial closure, 18 died and 19 survived and were discharged with a planned ventral hernia repair. Median length of intensive care unit and hospital stay were 5 (1–24) and 13 (8–35) days, respectively. After a mean follow-up of 21 months, telephone contact was possible with 14/19 patients who left the hospital with an abdominal hernia. Three reported hernia-related complications mandating surgical repair, while in 11, this was well tolerated.

Conclusion Routine skin-only closure during rAAA surgical repair results in low rates of ACS at the expense of a high rate of patients being discharged with a planned ventral hernia which, however, seems to be well tolerated by the majority of patients.

Keywords
- ruptured abdominal aortic aneurysm
- abdominal compartment syndrome
- intra-abdominal pressure
- open abdomen

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Introduction

Abdominal compartment syndrome (ACS) is a common complication after ruptured abdominal aortic aneurysm (rAAA) repair, which may have a major pathophysiological impact and significantly affect prognosis. Indeed, ACS has been reported to complicate rAAA repair in up to 20% of cases.[1,2] This is more pronounced among patients treated by open surgery compared to endovascular aneurysm repair (EVAR).[2] The pathophysiological background which can lead to the development of ACS may include hemorrhage, intestinal ischemia, or generalized bowel edema, but, irrespective of the cause, this condition has been identified as a significant predictor of mortality.[3] Indeed, Ersryd et al[4] suggest that ACS almost doubles postoperative mortality, which is 42 and 23% among those with and without ACS, respectively. Similar results have been reported by Rubenstein et al,[2] with respective mortality rates of 62 and 33%.

Upon diagnosis of ACS, decompression laparotomy is indicated to relieve intra-abdominal pressure (IAP) and prevent the ischemia of abdominal organs and its catastrophic consequences. Indeed, the 2013 World Society of the Abdominal Compartment Syndrome consensus management statement recommends decompressive laparotomy in cases of overt ACS rather than strategies that do not use decompressive laparotomy (GRADE 1D strength of recommendation).[5] Open abdomen can also be used in a preventive manner during the treatment of high-risk patients to prevent ACS development. Indeed, an open abdomen during the primary operation (prevention) has been shown to present favorable results compared to that during a secondary operation (treatment), with less intestinal ischemia, shorter duration of open abdomen, and less renal replacement therapy.[6] Overall, leaving the abdomen open in a prophylactic manner has been reported in up to 19% of cases after rAAA treatment, with an average value around 5 to 10%, mainly in cases with a tense abdomen that was difficult to close.[7–9] Several techniques have been used in patients who require open abdomen treatment, such as vacuum-assisted wound closure, mesh-mediated fascial traction, dynamic retention sutures, and the so-called Wittmann patch, which uses a nonpermeable Velcro patch, thus preventing lateralization but not permitting effective drainage.[7]

Skin-only closure of the abdomen after rAAA has been only scarcely reported in the literature. This technique could prevent ACS development in many cases, at the expense of a significant proportion of patients being left with a planned ventral hernia and accompanying complications. In our department, we routinely use skin-only closure in patients with rAAA repair. In this report, we summarize our experience with this technique.

Materials and Methods

Study Design and Patient Population

This is a single-center, retrospective descriptive study which included all consecutive patients treated for ruptured infrarenal or juxtarenal AAA during a 7-year period (January 2014 to December 2020). Open surgical repair was performed in all cases. The fact that currently EVAR is not offered for rAAAs at our department is the result of management logistics not allowing to stock endografts of all sizes onsite, while at the same time, the geographic isolation of our region from the endograft companies on mainland Greece results in a delayed acquisition of the endograft of 8 to 20 hours, depending on the time of day of patient admission. Typically, patients with suspected rAAA underwent a preoperative computed tomography (CT) scan, after which they were immediately transferred to the operating theater. A strategy of permissive hypotension is generally employed during the management of these patients and until definitive treatment, which according to current guidelines is beneficial for patients with rAAA.[10] In general, through a midline incision and transperitoneal access, the aorta was approached in order to obtain infrarenal aortic control. Suprarenal aortic clamping through the lesser omentum was only selectively used in case of anatomic constraints that would make infrarenal clamping challenging, such as proximal disease, significant angulation, morbid obesity, etc. The use of an aortic occlusion balloon, although a useful adjunct that can be used in selective cases, has not been used in the current series. Skin-only closure was routinely (meaning that this was our preferred approach and our primary treatment strategy) performed during the index operation, with a running or interrupted suture, while the abdominal fascia was left open to prevent ACS. Primary fascial closure was only selectively performed in cases deemed very low risk for the development of this complication (hemodynamically stable patients, with a small retroperitoneal hematoma and a straightforward surgical repair).

After the initial procedure, patients were transferred to the intensive care unit (ICU) where they were kept intubated and their clinical condition was reevaluated daily, to determine whether abdominal fascial closure could be performed. Reevaluation was based mainly on IAP recordings (at least twice/day using transbladder measurements), renal function, and acid–base balance. In general, an IAP <12 was required in order to attempt fascial closure. Moreover, acute kidney failure and the need for renal replacement therapy were considered a contraindication to definite abdominal closure.

If fascial closure was considered feasible, patients were transferred to the operating theater where this was performed. Otherwise, in case this was not considered safe, patients were progressively weaned and extubated and transferred from the ICU to a regular hospital bed. During the same admission, abdominal fascial closure was in some cases performed after a maximum of 7 days from the index operation. If this was not feasible, patients were discharged with a planned ventral hernia repair at a later time during another admission.

Collection of Data, Definitions, and Endpoints

Demographic information and hemodynamic condition of patients at presentation were recorded. The Edinburgh Scoring System (ERAS) was used to classify patients according to

their risk of mortality. ERAS is a scoring system which has been suggested for patients with rAAA because it is strikingly easy to use and has been shown to have a good correlation with the risk of mortality. ERAS takes into account only three parameters and assigns 1 to 3 points according to their values. Specifically, 1 point is assigned if hemoglobin < 9 g/dL, Glasgow Coma Scale <15, or systolic blood pressure <90 mm Hg, for a total score ranging from 0 to 3. A stepwise increase in ERAS was linked to a consecutive increase in mortality.[11]

Moreover, operative information such as type of incision, type of graft used (i.e., tube vs. bifurcated), need for transfusion, intraoperative mortality, and type of abdominal wound closure were also recorded.

Postoperatively rate of ACS, in-hospital mortality, length of hospitalization, and rate of definite abdominal closure were recorded. ACS was defined according to the updated consensus definitions and clinical practice guidelines from the World Society of the abdominal compartment syndrome published in 2013: sustained IAP >20 mm Hg (with or without an abdominal perfusion pressure (APP) <60 mm Hg) associated with new organ dysfunction/failure. The APP is defined as the mean arterial pressure (MAP) minus the IAP. Additionally, postoperative information such as hernia-related complications and the need for late hernia repair was also collected through telephone contact with patients.

Statistical Analysis

Quantitative data are summarized as mean values ± standard deviation if values are normally distributed and as median (range) if not. Qualitative data are reported as frequencies as appropriate (count and percentage).

Institutional review board approval was obtained for this study. Patient consent was obtained from participants.

Results

During the study period, the repair was attempted in 83 rAAA cases. There were 10 additional patients in whom repair was not undertaken because they were deemed too frail to undergo repair, died before reaching the operating theater, or refused treatment. Repair was performed with open surgery in every case. All patients had a preoperative CT scan. Retroperitoneal rupture was recorded in 75 patients, while this was free intraperitoneal in the remaining 8. The mean age of patients was 72.4 ± 10.5 years, and the vast majority were male (82:1). Mean systolic blood pressure at the time of presentation was 105 ± 15 mm Hg. Baseline systolic blood pressure < 90 mm Hg was recorded in 31 patients. The median ERAS score was 1 (0–3). Baseline characteristics of patients and perioperative variables are summarized in ►**Tables 1** and **2**, respectively. Demographic characteristics and comorbidities of patients are those of a typical AAA cohort with a high rate of male patients >70 years old who smoke. The 42% rate of cardiac disease may be a low proportion for such a patient group, which could be due to the strict criteria that have been used to define this variable. Including, a history of angina, previous myocardial infarction, arrhythmias, cardiac medication, and other clinical parameters would increase the proportion of patients with cardiac disease.

Table 1 Summary of baseline demographics and comorbidities

Demographics/Comorbidities	Total ($n = 83$)	
Age[a]	72.4 ± 10.5 y	
Male	82	99%
Hypertension	73	87%
Hyperlipidemia	62	75%
Diabetes mellitus	18	22%
Renal disease[b]	29	35%
Heart disease[c]	35	42%
COPD[d]	38	46%
Smoking	69	83%
AAA maximum diameter[a]	74 ± 9 mm	

Abbreviations: AAA, abdominal aortic aneurysm; COPD, chronic obstructive pulmonary disease.
[a]Mean ± standard deviation.
[b]Glomerular filtration rate < 60 mL/min/1.73 m^2
[c]Documented disease by coronary angiography or systolic or diastolic heart failure documented by echocardiography or diagnosis by cardiologist.
[d]Documented diagnosis with forced expiratory volume in 1 second <80% by spirometry or those taking relative medication.

Table 2 Perioperative variables

Perioperative variables	Total ($n = 83$)	
Retroperitoneal rupture	75	90%
Hemodynamic instability[a]	31	37%
ERAS score[b]	1 (0-3)	
ERAS score distribution	0: $n = 15$	
	1: $n = 34$	
	2: $n = 19$	
	3: $n = 15$	
Transfusion[b]	5 (2–19)	
ICU stay[b]	5 (1–24) d	
Hospital stay[b]	13 (8–35) d	
Mortality	29	35%
Renal failure[c]	48	58%
Intestinal ischemia[d]	19	23%
Acute limb ischemia[e]	9	11%

Abbreviations: ERAS, Edinburgh Scoring System; ICU, intensive care unit.
[a]Defined as systolic arterial pressure >90 mm Hg, at initial presentation.
[b]Median (range).
[c]Defined as need for temporary or permanent hemodialysis.
[d]Diagnosed with surgical exploration and requiring bowel resection.
[e]Mandating a revascularization procedure or a major amputation.

A median of 5 (2–19) units of red blood cells were given intraoperatively. Overall, 37 tube and 46 bifurcated grafts were used. Intraoperative mortality was recorded in nine cases, presenting with an ERAS score ≥2. Seventy-four patients left the operating theater alive and skin-only closure was used in 69 cases. In five cases, the rupture was small with a contained retroperitoneal hematoma, in hemodynamically stable patients with ERAS score 0, thus providing confidence that the development of ACS was unlikely, in these patients definitive abdominal closure with a continuous fascial suture was performed. All patients were transferred into the ICU postoperatively. ACS occurred in two patients in the skin-only closure group (2 and 4 days after rAAA repair). In these cases, sutures were removed and the abdomen was left open with a negative-pressure vacuum system. Both patients died in ICU. No cases of ACS were recorded among the five cases with primary fascial closure. Among the remaining 67 patients with skin-only closure, 30 patients experienced an uneventful postoperative course, with values of IAP <12 and without acute renal failure. In these cases, definite abdominal closure was performed, after a mean of 4 days from the index operation. All these patients survived the perioperative period. Among the remaining 37 patients, 18 died, and 19 survived, being discharged from the hospital with a planned ventral hernia. Median length of stay in ICU was 5 (1–24) days, while median total hospital stay was 13 (8–35) days. Total perioperative mortality was 34.9% (29/83). The flowchart of the study population is presented in ►**Fig. 1**.

Telephone contact was possible with 39 of 54 patients who were discharged after rAAA repair. The mean follow-up was 21 months. Among 35 patients with fascial closure, 25 were contacted and did not report any complications related to abdominal wall closure. Among 19 patients who were discharged with a planned ventral hernia repair, we could reach 14. Three reported a hernia-related complication and/or significant disability affecting their daily activities. These patients underwent hernia repair. The remaining 11 patients did not report any significant morbidity related to the hernia and did not opt for a hernia repair and a secondary abdominal fascial closure.

Discussion

In our single-center experience, routine skin-only closure of the abdominal wound after rAAA repair was linked to a very low ACS rate of 2.7%, at the expense of 35% of survivors being discharged with a planned ventral hernia and 21% of those requiring a ventral hernia repair due to complications. Taking into account that the main objective of the treatment of rAAA patients is to survive, one would argue that any useful adjunct at the time of the initial repair should be employed, even at the expense of additional morbidity or the need for additional operative management in the future. Indeed, with the approach we describe, only two cases of ACS were recorded among patients who survived rAAA surgical repair for a total rate of 2.7% (2/74). Notably, both patients

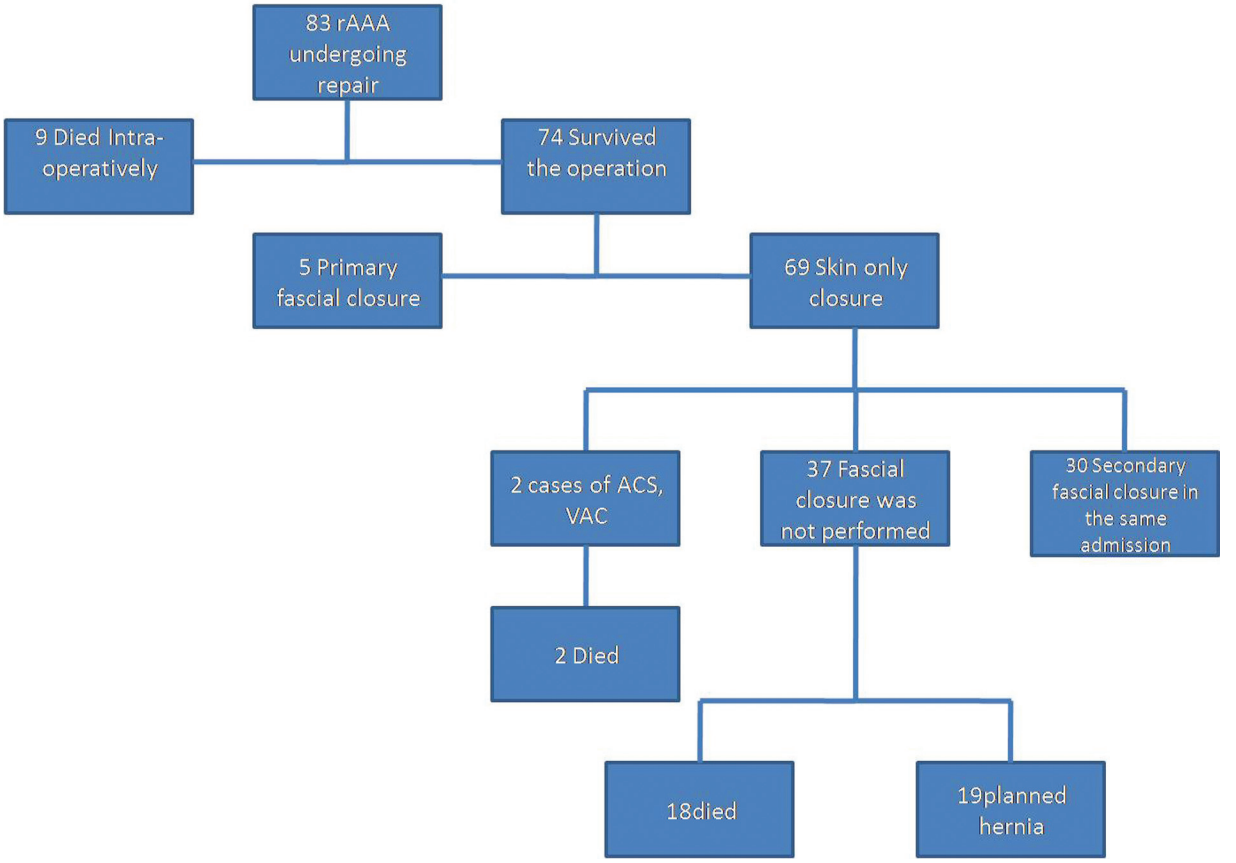

Fig. 1 Flowchart of the study population. ACS, abdominal compartment syndrome; rAAA, ruptured abdominal aortic aneurysm; VAC, vacuum-assisted closure.

died in the ICU a few days after the initial procedure despite the removal of sutures in the skin.

The rate of ACS after rAAA repair is variable, ranging from 3.7 to 35%. Ersryd et al,[3] in a recent study from the Swedvasc registry, recorded a 3.7% rate after open surgical repair (OSR) and 7.5% after EVAR for rAAA. A previous report from the same database recorded 6.8 and 6.9% ACS rates after OSR and EVAR for rAAA, respectively.[4] Contemporary single-center studies suggest much higher rates, such as from Rubenstein et al,[2] who reported a remarkably high ACS rate of 34% after OSR and 21% after EVAR. Mayer et al[9] reported that 20% of patients undergoing rAAA EVAR presented ACS. The reason behind this large variability in the incidence of ACS after rAAA repair is not clear. One possible explanation is that some studies do not use strict criteria to define ACS. Indeed, a systematic review of EVAR for rAAA recorded a pooled ACS rate of 8%, which increased to 17% when metanalysis was repeated after including only those studies that clearly defined ACS and 21% when only studies focusing on ACS were selected.[1] Clear definitions may be a significant problem, particularly when reporting results from registries, perhaps explaining the low ACS rates using the Swedvasc database. Overall, a 20% rate of ACS after rAAA repair would seem a reasonable, pragmatic, approximation.[12] The rate of ACS rate that has been found in the present study is much lower than those typically reported in the literature. Nevertheless, it should be underlined that even with skin-only abdominal closure, ACS is possible in extreme cases, like the two patients identified in the current series.

Since ACS has undoubtedly been identified as a possible complication after rAAA repair which significantly increases risk of mortality, most institutions have developed strategies for an early diagnosis. Therefore, close monitoring of patients in the immediate postoperative period, in the ICU setting, with abdominal pressure measurements several times per day is of paramount importance, in order not only to timely diagnose ACS but also to prevent it via nonoperative measures.[5] In most institutions, the prophylactic open abdomen is only used in a minority of patients in whom fascial closure is extremely difficult or impossible, probably because of the various hazards of this approach, such as high costs, exposure of abdominal viscera and grafts to infection, loss of heat and fluids, need for complex surgery to cover bowels, and finally to reconstruct the abdominal wall.[12] Of course different centers may keep a different threshold for leaving the abdomen open in a prophylactic manner, and a wide range of relevant rates has been reported in the literature. An algorithm to ensure timely diagnosis and treatment of ACS in patients with rAAAs is provided in the recent guidelines of the European Society for Vascular Surgery. This suggests, at first, conservative management and if this proves unsuccessful, decompression is indicated.[10] We propose an alternative strategy, where the fascial layer is left open routinely, in an effort to prevent ACS. This would not qualify for the definition of open abdomen according to the formal statement provided in current guidelines,[5] which requires both the abdominal fascia and the skin to be left open. This approach may represent an attractive alternative, deferring tight abdominal closure for a later time. The remaining patients are discharged from the hospital, with a planned ventral hernia. This needs surgical treatment in less than 25% of patients. This abdominal hernia may cause discomfort or occasionally intestinal obstruction due to adhesions, but not the severe and potentially lethal complications of a true open abdomen (such as contamination, fixity, entero-atmospheric fistula, etc.).[7] The majority of patients tolerate this condition well. Actually, one could argue that the routine skin-only closure approach proposed here is the "medio tutissimus ibis" (the middle course is the safest and best) between fascial closure and open abdomen for the prevention of ACS. Skin-only closure might also facilitate subsequent fascial closure by preventing lateralization of the rectus muscles which usually occurs about 5 to 7 days postoperative and prevents fascial closure with conventional surgical techniques.

The present findings should be interpreted in the context of the limitations of this study. The main limitation is the small number of participants and the limited follow-up period. Secondly, some patients were lost to follow-up, and therefore, their outcome is uncertain. Thirdly, this report is limited by its observational, retrospective design, which makes it subject to selection and recall bias. Nevertheless, to our knowledge this is the first published report to evaluate the results of routine skin-only closure after rAAA repair, These preliminary results provide encouraging grounds for further studies to delineate the possible value of this method during treatment of these marginal patients.

Conclusion

Routine skin-only closure after rAAA surgical repair results in very low rates of ACS. On the contrary, a significant minority of patients are discharged with a planned ventral hernia, which nevertheless, is well tolerated in most cases. Taking everything into account, the benefits of a routine skin-only closure approach to prevent ACS development likely outweigh the risks associated with a planned ventral hernia.

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Conflict of Interest
The authors declare no conflict of interest related to this article.

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References

1 Karkos CD, Menexes GC, Patelis N, Kalogirou TE, Giagtzidis IT, Harkin DW. A systematic review and meta-analysis of abdominal compartment syndrome after endovascular repair of ruptured abdominal aortic aneurysms. J Vasc Surg 2014;59(03):829–842
2 Rubenstein C, Bietz G, Davenport DL, Winkler M, Endean ED. Abdominal compartment syndrome associated with endovascular

and open repair of ruptured abdominal aortic aneurysms. J Vasc Surg 2015;61(03):648–654
3 Ersryd S, Djavani Gidlund K, Wanhainen A, Smith L, Björck M. Editor's choice—abdominal compartment syndrome after surgery for abdominal aortic aneurysm: subgroups, risk factors, and outcome. Eur J Vasc Endovasc Surg 2019;58(05):671–679
4 Ersryd S, Djavani-Gidlund K, Wanhainen A, Björck M. Editor's choice—abdominal compartment syndrome after surgery for abdominal aortic aneurysm: a nationwide population based study. Eur J Vasc Endovasc Surg 2016;52(02):158–165
5 Kirkpatrick AW, Roberts DJ, De Waele J, et al; Pediatric Guidelines Sub-Committee for the World Society of the Abdominal Compartment Syndrome. Intra-abdominal hypertension and the abdominal compartment syndrome: updated consensus definitions and clinical practice guidelines from the World Society of the Abdominal Compartment Syndrome. Intensive Care Med 2013;39 (07):1190–1206
6 Acosta S, Seternes A, Venermo M, et al. Open abdomen therapy with vacuum and mesh mediated fascial traction after aortic repair: an international multicentre study. Eur J Vasc Endovasc Surg 2017;54(06):697–705
7 Björck M, Wanhainen A. Management of abdominal compartment syndrome and the open abdomen. Eur J Vasc Endovasc Surg 2014; 47(03):279–287
8 Oelschlager BK, Boyle EM Jr, Johansen K, Meissner MH. Delayed abdominal closure in the management of ruptured abdominal aortic aneurysms. Am J Surg 1997;173(05):411–415
9 Mayer D, Rancic Z, Meier C, Pfammatter T, Veith FJ, Lachat M. Open abdomen treatment following endovascular repair of ruptured abdominal aortic aneurysms. J Vasc Surg 2009;50(01):1–7
10 Wanhainen A, Verzini F, Van Herzeele I, et al; Esvs Guidelines Committee. Editor's Choice—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(01):8–93
11 Krenzien F, Wiltberger G, Hau HM, et al. Risk stratification of ruptured abdominal aortic aneurysms in patients treated by open surgical repair. Eur J Vasc Endovasc Surg 2016;51(01): 30–36
12 Björck M. Management of the tense abdomen or difficult abdominal closure after operation for ruptured abdominal aortic aneurysms. Semin Vasc Surg 2012;25(01):35–38

