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· 血管外科专题研究 ·

## 规范急诊流程下破裂腹主动脉瘤腔内修复的近、中期疗效

肖悦, 郭媛媛, 郭修海, 陈澄

(云南省阜外心血管病医院/昆明医科大学附属心血管病医院 血管外科, 云南 昆明 650102)

### 摘要

**背景与目的:** 腹主动脉瘤破裂 (rAAA) 是腹主动脉瘤最严重的并发症, 病情发展迅速, 病死率高, 及时的诊断和治疗极其关键, 目前腔内治疗作为一线选择。本文分析探讨规范急救流程下动脉瘤腔内修复术 (EVAR) 治疗 rAAA 的安全性、有效性, 以及近、中期疗效。

**方法:** 回顾性分析 2018 年 1 月—2024 年 10 月在云南省阜外心血管病医院接受 EVAR 的 22 例 rAAA 患者的临床资料。男 16 例, 女 6 例, 年龄 ( $67.2 \pm 10.0$ ) 岁, 瘤体最大径 ( $70.6 \pm 9.2$ ) mm, 均为肾下型 rAAA, 瘤颈角度 ( $107.9 \pm 54.3$ ) $^{\circ}$ 。所有患者术前均通过全主动脉+冠脉 CT 血管造影 (CTA) 确诊, 所有患者在规范急救流程下行 EVAR。收集患者围手术期临床资料, 术后 1 周与 1、6、12 个月及之后每年 1 次随访 CTA 资料, 分析瘤腔血栓化率、支架形态、内漏形式及发生率、髂分支通畅率等。

**结果:** 手术成功率为 100%; 术中支架植入后造影发生 I 型内漏 6 例, 通过球囊扩张、植入短支架及弹簧圈+生物蛋白胶填充瘤腔等技术处理, 再次造影内漏消失或明显减少。平均手术时间 ( $162.1 \pm 63.6$ ) min, 输悬浮红细胞 ( $736.4 \pm 532.3$ ) mL, 术后外科重症监护病房治疗时间 ( $8.76 \pm 1.0$ ) h, 平均住院时间 ( $8.1 \pm 4.5$ ) d。术后 30 d 死亡 6 例, 2 例患者术后 1 周复查 CTA 发现少许 II 型内漏, 未予特殊处理, 术后 1 个月复查内漏减少, 术后 3~6 个月, 内漏消失; 1 例患者于术后 2 年发生 Ib 型内漏, 遂二次干预, 内漏消失; 其余患者支架无内漏, 无髂支闭塞, 瘤腔血栓化程度满意。

**结论:** 规范急救流程下 EVAR 治疗 rAAA 安全有效, 近中期疗效满意, 对于 I 型内漏可借助球囊扩张、植入短支架及弹簧圈+生物蛋白胶填充瘤腔等技术予以处理, 疗效安全可靠。

### 关键词

主动脉瘤, 腹; 动脉瘤, 破裂; 内漏

中图分类号: R654.3

## Short- and mid-term outcomes of endovascular repair for ruptured abdominal aortic aneurysms under standardized emergency protocols

XIAO Yue, GUO Yuanyuan, GUO Xiuhai, CHEN Cheng

(Department of Vascular Surgery, Fuwai Yunnan Hospital, Chinese Academy of Medical Sciences/Affiliated Cardiovascular Hospital of Kunming Medical University, Kunming 650102, China)

### Abstract

**Background and Aims:** Ruptured abdominal aortic aneurysm (rAAA) is the most severe complication

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**作者简介:** 肖悦, 昆明医科大学附属心血管病医院/云南省阜外心血管病医院硕士研究生, 主要从事血管外科方面的研究。

**通信作者:** 郭媛媛, Email: guoyuanyuanxy@126.com

of abdominal aortic aneurysms, characterized by rapid progression and high mortality. Timely diagnosis and treatment are critical, with endovascular aneurysm repair (EVAR) currently serving as the first-line treatment. This study was conducted to evaluate the safety, efficacy, and short- to mid-term outcomes of EVAR for rAAA under standardized emergency protocols.

**Methods:** The clinical data of 22 patients with rAAA who underwent EVAR at Yunnan Fuwai Cardiovascular Hospital from January 2018 to October 2024 were retrospectively analyzed. The cohort included 16 males and 6 females, with a mean age of (67.2±10) years. The mean maximum aneurysm diameter was (70.6±9.2) mm, and all cases were infrarenal rAAA with a mean aneurysm neck angle of (107.9±54.3)°. All patients were diagnosed preoperatively via total aortic and coronary computed tomography angiography (CTA) and treated with EVAR under standardized emergency protocols. Perioperative clinical data, along with follow-up CTA findings at 1 week, 1 month, 6 months, 12 months, and annually thereafter, were collected. Outcome measures included aneurysm sac thrombosis rate, stent morphology, type and incidence of endoleaks, and iliac branch patency rate.

**Results:** The procedural success rate was 100%. Intraoperative angiography revealed type I endoleak in 6 cases, which were successfully managed using balloon dilation, short stent implantation, or a combination of coil embolization and biologic glue to seal the aneurysm sac. Post-treatment angiography showed resolution or significant reduction of the endoleak. The mean operative time was (162.1±63.6) min, with an average transfusion of (736.4±532.3) mL of packed red blood cells. After operation, the average stay in the SICU was (8.76±1.0) h, and the mean hospital stay was (8.1±4.5) d. There were 6 deaths within 30 d after operation. Two patients had minor type II endoleak detected on CTA at 1 week, which required no special intervention; these endoleaks reduced by 1 month and resolved by 3–6 months. One patient developed a type Ib endoleak at 2 years after operation, which was successfully managed with reintervention. The remaining patients had no endoleaks, no iliac branch occlusions, and satisfactory aneurysm sac thrombosis.

**Conclusion:** EVAR under standardized emergency protocols is safe and effective for treating rAAA, with satisfactory short- and mid-term outcomes. Type I endoleak can be reliably managed using techniques such as balloon dilation, short stent implantation, and coil embolization with biologic glue, demonstrating a safe and effective treatment approach.

#### Key words

Aortic Aneurysm, Abdominal; Aneurysm, Ruptured; Endoleak

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腹主动脉瘤破裂 (ruptured abdominal aorticaneurysm, rAAA) 是腹主动脉瘤最严重的并发症, 病情发展迅速, 即使接受急诊手术的患者仍有 40%~50% 的病死率<sup>[1-2]</sup>。对于 rAAA 及时的诊断和治疗极其关键, 手术方式包括传统正中开腹行瘤体切除并人工血管置换, 以及动脉瘤腔内修复术 (endovascular aneurysm repair, EVAR)。虽然研究认为 EVAR 术后再干预率较开放手术高<sup>[3]</sup>, 但就 rAAA 而言, EVAR 有创伤小, 手术时间短等优势, 病死率与开放手术 (open surgery, OS) 相比无差异<sup>[4-5]</sup>。随着 EVAR 技术的不断进步, 其在抢救

rAAA 方面优势愈显。指南亦推荐解剖条件合适时可采用腔内方式治疗 rAAA<sup>[6-8]</sup>。规范化的急救流程对提高抢救成功率尤为重要, 2018 年 1 月—2024 年 10 月云南省阜外心血管病医院血管外科在规范化急救流程下, 应用 EVAR 救治了 22 例患者, 并进行了近、中期随访, 现报告如下。

## 1 资料与方法

### 1.1 一般资料

回顾性收集 2018 年 1 月—2024 年 10 月云南省

阜外心血管病医院血管外科收治的 22 例接受 EVAR 治疗 rAAA 患者的病历资料, 其中男 16 例, 女 6 例; 年龄 40~86 岁。所有患者以剧烈腰背痛为首发症状就诊, 6 例患者入急诊科时已经出现低血压休克, 经补液输血等积极抢救血压好转, 得以实施手术。所有患者在急诊科开通静脉通路, 行全主动脉+冠脉 CT 血管造影 (computer tomographic angiography, CTA)、床旁心电图、心脏彩超, 确诊后立即转运至杂交手术室。从急诊科到手术室的时间范围为 28~110 min。20 例患者在全麻气管插管下手术, 2 例在局麻下完成手术。所有患者均已获得知情同意, 本研究获得云南省阜外心血管病医院伦理委员会批准 (批号: 2024-094-02)。患者一般情况见表 1。

表 1 22 例行 EVAR 治疗 rAAA 患者一般情况

Table 1 General characteristics of 22 rAAA patients undergoing EVAR

项目	数值
性别[n(%)]	
男	16(72.7)
女	6(27.3)
年龄(岁, $\bar{x} \pm s$ )	67.2±10.0
术前血红蛋白浓度(g/L, $\bar{x} \pm s$ )	111.1±33.1
术前平均动脉压(mmHg, $\bar{x} \pm s$ )	83.1±17.4
合并症[n(%)]	
冠心病	
单支	5(23.0)
双支	2(9.1)
三支	2(9.1)
长期存在的高血压	19(86.4)
失血性休克表现	6(27.3)
慢性阻塞性肺疾病	1(4.5)
解剖学特点[n(%)]	
合并单侧髂动脉瘤	3(13.6)
合并双侧髂动脉瘤	11(50.0)
瘤体直径(cm, $\bar{x} \pm s$ )	69.0±15.6
瘤颈直径(cm, $\bar{x} \pm s$ )	17.0±2.9
瘤颈长度(cm, $\bar{x} \pm s$ )	14.7±2.4
瘤颈角度( $^{\circ}$ , $\bar{x} \pm s$ )	107.9±54.3

### 1.2 手术方法

入手术室后迅速颈静脉置管补液、右桡动脉穿刺测压, 同时麻醉医生积极纠正休克。利用 GE 工作站 (General Electric 公司, IGS730RAW) 重建 CTA 图像, 确定低位肾动脉最佳展开角度, 明确机头位置。所有患者穿刺双侧股动脉和左侧肱动

脉, 双股动脉分别预埋两把缝合器, 交换大鞘 (埃普特 18~20 F, 25 cm), 经一侧股动脉置入超硬导丝建立覆膜支架主体通路, 对侧股动脉猪尾导管放置于 T10~11, 按预设角度打机头位置, 进行主动脉瘤造影。同时经该侧大鞘预留椎动脉导管在瘤腔中, 以备弹簧圈或生物胶填塞。结合 CTA 及造影结果, 选择合适型号的腹主动脉覆膜支架主体 (放大率 25%~30%), 紧贴低位肾动脉下缘, 释放主体支架。迅速经肱动脉入路交换导丝, 接入对侧髂支。使用球囊 (COOK 公司, CODA 球囊 46 mm) 扩张近、远端锚定区及各支架连接处, 使支架各段充分贴合, 减少内漏发生。再次造影, 观察覆膜支架血流是否通畅, 有无内漏, 若术中发现 I 型内漏, 如果低位肾动脉远端还有锚定区, 则加用 Cuff 支架 (与主体同口径, 长度 45 mm), 如低位肾动脉远端已经无空间, 则通过预置的椎动脉导管, 在瘤颈与支架间置入可控弹簧圈及生物蛋白胶进行填充, 并用 CODA 球囊充分扩张支架“裤腰”, 加强支架与血管壁贴合。再次造影确认无内漏, 或内漏明显减少后, 撤出输送器, 收紧缝合器线结, 闭合穿刺点。术后患者均转入外科重症监护病房 (SICU) 观察治疗 (图 1)。

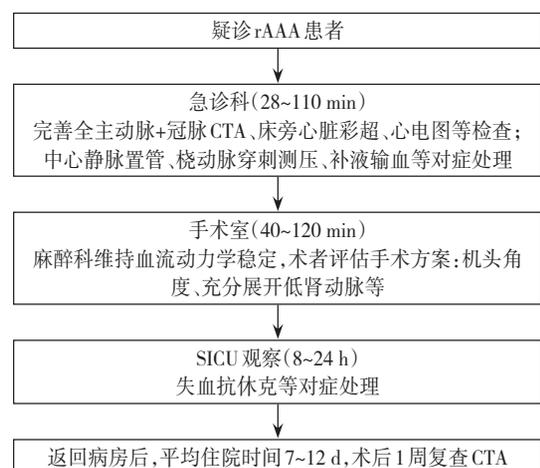


图 1 rAAA 患者规范化急救流程图

Figure 1 Standardized emergency protocol for rAAA patients

### 1.3 随访

所有患者术后 1 周复查 CTA 后出院, 随后分别于术后 1、3、6、12 个月及之后每年 1 次进行 CTA 复查, 随访内容包括生存状况、CTA 评估有无内漏、瘤腔隔绝情况、有无支架移位和其他并发症。

## 2 结果

### 2.1 手术结果

所有患者成功植入覆膜支架，手术无中转开放手术（表2）。6例瘤颈短或扭曲的患者支架植入后造影，存在I型内漏，其中3例低位肾动脉下尚有3~5 mm锚定区，予加入Cuff支架（Medtronic公司，45 mm），并通过预留的椎动脉导管，在内漏部位填塞可控弹簧圈+生物蛋白胶，CODA球囊充

分扩张瘤颈，再次造影I型内漏消失（典型不良瘤颈患者情况与处理见图2-4）。余3例低位肾动脉下已无锚定空间，通过预留的椎动脉导管填塞可控弹簧圈+生物蛋白胶，CODA球囊充分扩张瘤颈，再次造影内漏显著减少。2例患者术中造影可见少许II型内漏，来源于肠系膜下动脉，开放双侧股动脉后，经肱动脉通路造影，内漏明显减少，未再予特殊处理。

表2 22例患者手术相关情况  
Table 2 Surgery-related data of 22 patients

项目	数值
机头照射角度[n(%)]	
左前斜位30°/头位25°	4(18.2)
左前斜位10~20°/头位10~20°	12(54.5)
左前斜位10°/头位10°以内	6(27.3)
近端Cuff支架植入[n(%)]	3(13.6)
单侧髂内动脉覆盖[n(%)]	5(22.7)
瘤腔弹簧圈+生物胶[n(%)]	6(27.3)
从急诊进入手术室时间(min, 范围)	28~110
手术时间(首次造影—支架植入后造影)(min, 范围)	30~70
SICU观察时间(h, $\bar{x} \pm s$ )	8.76±1.0
住院时间(d, $\bar{x} \pm s$ )	8.5±4.7
输注悬浮红细胞(mL, $\bar{x} \pm s$ )	736.4±532.3
输注血小板[n(%)]	1(4.5)

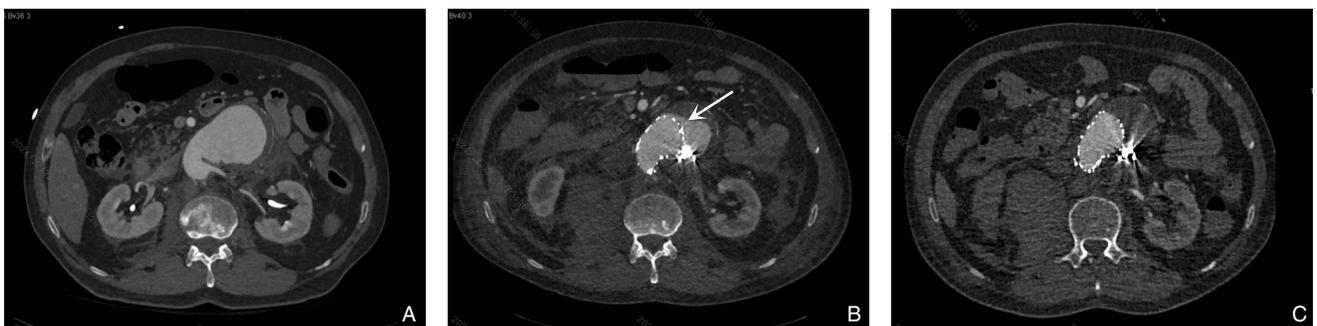
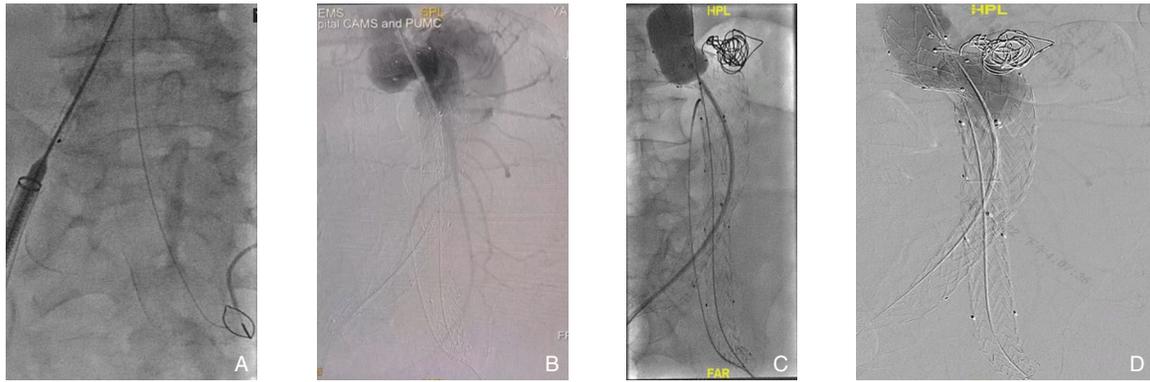


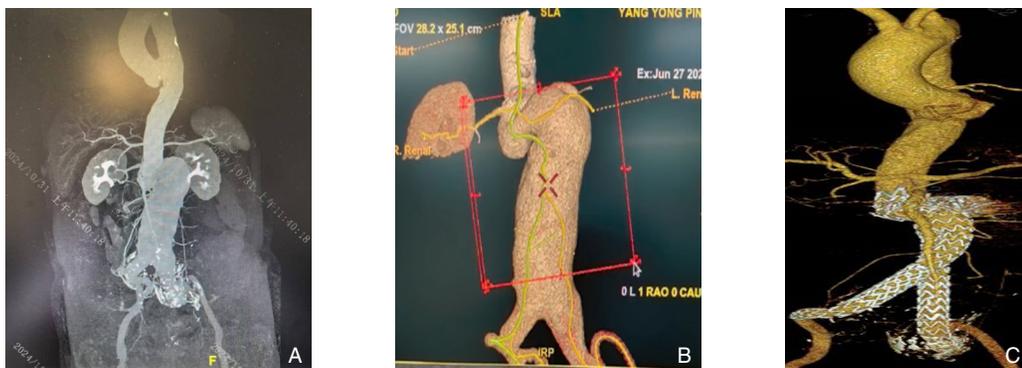
图2 CTA资料 A: 瘤颈严重扭曲; B: 术后3 d, 瘤体内存在少量内漏; C: 术后1周, 内漏消失

Figure 2 CTA findings A: Severe tortuosity of the aneurysm neck; B: Minimal endoleak within the aneurysm sac 3 d after operation; C: Resolution of the endoleak 1 week after operation



**图3 术中造影资料** A: 术中经肱动脉途径将导丝送入左髂动脉, 抓捕器抓出导丝, 建立左侧髂腿通路; B: 支架植入后造影可见I型内漏; C: 经预留的椎动脉导管在瘤颈周边置入可控弹簧圈+生物蛋白胶, CODA球囊充分扩张; D: 再次造影, I型内漏明显减少

**Figure 3 Intraoperative angiography findings** A: Guidewire advanced into the left iliac artery via the brachial artery and retrieved using a snare to establish the left iliac limb pathway; B: Angiography after stent deployment showing type I endoleak; C: Controlled coil embolization with biologic glue applied around the aneurysm neck via the reserved vertebral artery catheter, followed by full expansion with a CODA balloon; D: Repeat angiography showing a significant reduction in the type I endoleak



**图4 CTA重建资料** A: 术前CTA重建图像; B: 通过GE工作站充分展开瘤颈, 预判机位; C: 术后1周CTA重建图像

**Figure 4 CTA reconstruction images** A: Preoperative CTA reconstruction; B: Aneurysm neck fully expanded and operative position pre-assessed using the GE workstation; C: Postoperative CTA reconstruction at 1 week

## 2.2 术后30 d内患者死亡情况

术后24~72 h, 3例患者经输血、补液等纠正休克治疗后仍无法纠正术前即存在的低血压, 最终死亡。除上述3例患者外, 术后30 d内死亡3例, 1例患者术后1周复查全主动脉CTA, 瘤体隔绝良好, 无内漏, 但患者出院前突发室颤, 经抢救无效死亡, 推测死因为急性冠脉综合征; 1例患者于术后3 d复查瘤体未增大, 瘤腔中残留少许造影剂, 患者无腹痛, 生命征平稳, 由SICU转回普通病房, 但术后5 d突发呼吸心脏骤停, 抢救过程中出现腹部张力增高, 推测死于瘤体再发破裂; 1例患者术后8 h血压、心率、呼吸渐趋平稳, 清醒后在SICU拔除气管插管, 患者自述已无腹痛, 但存在腹胀, 查体腹部张力较术前无明显改善, 未闻

及肠鸣音, 床旁彩超提示腹膜后血肿约10 cm × 9 cm, 未见活动性血流, 在SICU继续对症处理过程中, 于术后13~17 h出现双吸状态下氧饱和度下降, 再次插管, 虽然多次复查床旁彩超提示腹膜后血肿未明显增大, 但出现少尿, 推测血肿压迫已出现腹腔间隔室综合征表现, 建议急诊剖腹探查, 清除血肿并行人工血管置换, 患者家属拒绝, 继续在SICU治疗, 1周后死于腹腔间隔室综合征继发多器官功能衰竭。

## 2.3 出院患者随访结果

本组22例患者中, 出院16例, 3例完成了术后1~6个月随访, 其中13例完成了术后6个月至1年随访, 4例完成了1~3年全程随访。16例出院患者随访期未出现臀部缺血、心脑血管等并发症。2例

术中存在少许Ⅱ型内漏的患者, 1~3个月后复查, 内漏明显减少, 未影响瘤体血栓化, 未引起瘤体增大。1例患者于2年后发生Ib型内漏, 局麻下使用球囊扩张, 接入髂腿延长支, 内漏消失。其余患者动脉瘤腔被有效隔绝, 血栓化程度好, 支架与血管壁贴合良好, 血流通畅, 肾动脉显影正常, 无再发破裂, 支架无内漏或移位, 瘤腔血栓化程度良好。

### 3 讨论

rAAA的最佳手术治疗方式一直存在争议, 现有文献认为: 即使解剖条件不佳, 也不应作为腔内治疗的绝对禁忌证<sup>[9-11]</sup>, 无论选择哪种术式, 不良的解剖瘤颈都会对手术预后产生不利影响<sup>[12]</sup>。本文基于临床实践的结果, 将EVAR作为rAAA的优先选择, 数据显示, 24 h院内病死率、术后30 d和1年后的病死率与现有大部分研究<sup>[13-14]</sup>一致。多篇分析结果中, 也全面论证了EVAR围手术期病死率低于OS, 本研究结果也表明EVAR作为优先选择可获得较好的近中期结果。这与我院的规范化急救流程有关: (1) 针对rAAA患者, 设有“绿色通道”, 所有患者在急诊科可快速完成全主动脉+冠脉CTA、床旁心脏彩超等相关术前检查, 同时进行输血补液抢救休克。本组术前准备最快28 min完成, 为迅速实施手术创造了条件; (2) 急诊科—血管外科—手术室—麻醉科—SICU迅速联动, 制定抢救方案。所有患者CTA由术者或一助经GE工作站重建图像, 确定低位肾动脉最佳展开时机头投照角度, 减少造影次数及造影剂剂量; 所有患者建立左肱动脉通路, 减少在巨大的破裂瘤腔中“选腿”的时间; (3) 我院覆膜支架品种型号备货齐全, 减少了厂家—代理商备货环节。上述规范化流程, 为患者极大争取了抢救时间。

rAAA的麻醉方式亦有争议。局麻对血流动力学稳定的患者, 可降低围术期病死率<sup>[15-17]</sup>, 但在急诊情况下, 血流动力学紊乱的患者, 往往无法保持制动, 术中造影时存在运动伪影干扰手术进程。针对已有失血性休克等情况的患者, 全麻诱导过程中可能进一步降低患者血压而导致死亡。有学者提出: 可首先在局麻下球囊阻断腹主动脉近端, 减少出血, 再行气管插管全麻, 为EVAR争取时间。本组仅2例在局麻下完成手术, 效果良好, 不

排除将来进一步探索局麻下实施EVAR, 其余患者均在手术团队和麻醉团队密切配合下, 诱导开始即同时建通路, 插管完成立即造影, 最大限度争取了时间。EVAR能够最小化生理紊乱, 有利于rAAA患者的生存, 尤其是对于那些血流动力学已经不稳定的患者, 这也解释了EVAR病死率下降的另一个原因<sup>[18]</sup>。

与开放手术彻底切除瘤体不同, EVAR后大量被“隔绝”的血液不能进入有效血循环, 这导致术后血红蛋白会随瘤腔血栓化而不断下降, 对于合并冠心病的患者, 术后心肌缺血风险较大。术前血液制品的替代和血流紊乱的纠正尤为关键<sup>[19]</sup>。过度的液体置换会加剧出血, 对血流动力学受损的患者造成损害, 因此, 需避免过度容量置换, 控制出血并维持控制性降压, 可减少大量出血, 并有助于血栓形成。同时由于动脉瘤破裂, 大量血小板及凝血因子被消耗, 最佳的输血方式是使用红细胞悬液、新鲜冰冻血浆、血小板悬液等。本组9例患者合并冠脉病变, 在确诊后立即开始纠正低血容量性休克, 围手术期严控出入量, 适当输血, 尽可能减少术后发生低血容量或低氧诱发急性冠脉综合征, 仍然有1例冠脉单支病变患者术后死于急性心肌梗死。鉴于rAAA患者绝大多数合并冠脉病变, 围手术期应充分重视维持冠脉血供及减少心脏负荷间的平衡。

然而, EVAR并非完全没有并发症, 大多数rAAA为不良近端瘤颈, 给EVAR带来了巨大的技术挑战<sup>[10,20-21]</sup>, 如瘤颈短粗、钙化、严重扭曲、形态不规则等, 增加了内漏风险。本组患者19例为不良近端瘤颈, 术中处理方法包括: 预判投照机位、充分展开低肾动脉以减少造影剂使用量及手术时间; 梯形瘤颈支架放大率以“梯形”下缘为标准选支架, 支架放大率可增至25%~30%; 极短瘤颈使用大球囊充分扩张“裤腰”, 增加支架与瘤颈的贴附; 急诊状态下, 应尽量避免采用过多手段重建内脏分支, 使手术复杂化, 必要时可补加Cuff支架, 或在瘤颈周边充分填塞可控弹簧圈及生物蛋白胶, 减少内漏。

不良近端瘤颈导致的Ia型内漏是术后死亡的主要原因<sup>[22-24]</sup>。本组6例支架植入后存在Ia型内漏。经添加Cuff支架、填塞弹簧圈+生物胶、反复球囊扩张后, 内漏消失或明显减少, 术后多次复查CTA, 可见瘤腔内少量造影剂残留, 但瘤体未

进行性增大。1例患者术后再发破裂,不排除内漏增加所导致。1例患者术后2年出现Ib型内漏引起再发破裂,系髂总动脉持续扩张所致,瘤腔填塞+髂支架延长至髂外动脉解决问题。

因此,术后定期复查有助于早期发现并发症并进行干预。除了早期发现内漏外,术后还可能发生植入物感染,支架感染的诊断较为困难,仅凭非特异性的腰背痛、发热等临床表现难以做出正确诊断。增强CT扫描能够提供更多的信息,包括主动脉周围的炎症迹象如脂肪垫消失、瘤壁增厚伴强化、瘤体周围液体积聚及瘤腔内气泡影等<sup>[25-26]</sup>;支架感染的发生率约在0.2%~0.7%之间,最常见于术后1~3年<sup>[27-28]</sup>。移植物感染预后极差,需要手术取出感染的支架及周围组织,进行血运重建,并长期抗感染治疗。对于此类患者的手术时机、血运重建模式尚无标准化指南,本组随访期尚无移植物感染病例。

综上所述,规范化急救流程,多学科高效协作是提高rAAA救治率的关键<sup>[29]</sup>,包括急诊科早识别,迅速进行循环复苏,为急诊手术创造条件;手术室及麻醉科配合,持续复苏循环,稳定血流动力学,保障术中安全;手术方案尽量“简单”,加快手术速度;术后生命支持如纠酸、纠正失血性休克、预防感染等<sup>[30]</sup>,缺一不可。尽管EVAR已成为最常用的技术,并且在短期和中期效果相对较好,但其长期疗效和持久性仍需进一步观察。此外,仍有一部分rAAA患者不适合腔内治疗,在解剖和技术困难可能增加血管内手术失败风险的情况下,仍需做好开腹手术的准备。

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作者贡献声明:肖悦负责书写原稿;郭媛媛负责手术实施、研究设计、文章审核和修改;郭修海和陈澄负责手术实施、数据采集及整理。

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