

负压封闭引流技术腹部应用指南



扫一扫下载指南全文

中国医师协会创伤外科医师分会

通信作者:张连阳, Email:dpzhangly@163.com, 电话:13508308400; 白祥军, Email:baixiangjun@hotmail.com, 电话:13907197594

【摘要】 在腹部外科临床实践中,经常需要应用负压封闭引流(VSD)技术,但缺乏相关应用规范或指南。为及时反映当今腹部外科应用 VSD 技术的新理念和循证医学进展、优化腹部外科中 VSD 技术的应用策略、规范医疗行为,中国医师协会创伤外科医师分会在 2017 年 7 月组织全国 28 名专家综合相关文献,遵循科学性、实用性和先进性的原则,制订了临床“负压封闭引流技术腹部应用指南”。该指南针对腹部外科中 VSD 技术应用最为重要的 11 个问题提出了基于循证医学证据的建议。

【关键词】 实践指南; 负压伤口疗法; 腹部损伤; 负压封闭引流
DOI:10.3760/cma.j.issn.1001-8050.2019.04.001

Guideline for application of vacuum sealing drainage in abdominal surgery

Trauma Surgeons Branch of Chinese Surgeons Association

Corresponding authors: Zhang Lianyang, Email: dpzhangly@163.com, Tel: 0086-13508308400; Bai Xiangjun, Email: baixiangjun@hotmail.com, Tel: 0086-13907197594

【Abstract】 In the clinical practice of abdominal surgery, vacuum sealing drainage (VSD) is often needed, but there are no relevant application norms or guidelines. In order to timely reflect the new concept of applying VSD in abdominal surgery and the progress of evidence-based medicine, optimize the application strategy of VSD technology in abdominal surgery, and standardize medical behavior, the Traumatic Surgeon Branch of Chinese Medical Association organized 28 experts in July 2017 to synthesize the relevant literature. Following the principles of scientificity, practicability and advancement, we formulated a clinical application guideline for negative pressure sealing drainage technology for abdomen. The guidelines provide evidence-based medical advice on 11 core issues in VSD for abdominal surgery.

【Key words】 Practice guideline; Negative-pressure wound therapy; Abdominal injuries; Vacuum sealing drainage

本文首次发表于 Chin J Traumatol, 2019, 22(1):1-11
DOI:10.3760/cma.j.issn.1001-8050.2019.04.001

负压封闭引流(vacuum sealing drainage, VSD)技术的历史最早可追溯到 1954 年,Redon 等^[1]首次提出真空负压伤口引流技术的概念,并于 1959 年将真空负压伤口引流装置 Sterimed 应用于外科临床,达到了增强引流效果、减少感染、促进伤口愈合的目的。1964 年,McClean 等^[2]描述了伤口封闭负压吸引在头颈外科手术中的作用。1977 年,Fox 等^[3]首先提出持续负压吸引可加速创面愈合的观点。1992 年,德国 Ulm 大学附属创伤外科医院的 Fleischmann 等^[4-5]原创了 VSD 技术,将传统负压引流与现代封闭性敷料相结合,用于治疗四肢感染创面,取得了显著疗效;1995 年,武汉大学中南医院裘华德教授首

次将 VSD 技术应用于腹部^[6];1997 年,部分学者采用多孔聚氨酯海绵材料治疗慢性难治性创面,引流效果更好,并提出负压创面治疗(negative - pressure wound therapy, NPWT)和负压辅助封闭(vacuum - assisted closure, VAC)技术^[7-8]。2008 年,VSD 技术被纳入中国卫生部“十年百项”推广计划。VSD 技术涵盖“负压、封闭和引流”的外科理念,包括 NPWT 和 VAC 技术,本文中 VSD 技术为此三类技术的统称。近年来,VSD 技术在腹部外科临床实践中使用越来越广泛,但缺乏相关应用规范或指南。为及时反映当今腹部外科应用 VSD 技术的新理念和循证医学进展、优化腹部外科中 VSD 技术的应用策略、

规范医疗行为,2017 年 7 月中国医师协会创伤外科医师分会组织全国 28 名专家综合相关文献,遵循科学性、实用性和先进性的原则,制订了临床“负压封闭引流技术腹部应用指南”。本指南针对腹部外科中 VSD 技术应用最为重要的 11 个问题提出了基于循证医学证据的建议。

1 文献检索与证据分级

以“VSD or vacuum sealing drainage”“NPWT or negative pressure wound therapy”“vacuum - assisted closure”“topical negative pressure”“负压封闭引流”“负压辅助封闭”为关键词,检索 PubMed、MEDLINE、Cochrane Library、OVID、Elsevier、中国生物医学文献数据库(CBM)、中国知网、维普、万方数据知识服务平台等数据库,检索时间从建库至 2017 年 9 月。手工检索相关杂志、会议论文及未发表的灰色文献等。

利用牛津循证医学证据水平分级评估证据的质量和评级推荐水平^[9]。证据水平分级如下:1a 级,同质性随机临床试验(RCTs)的系统综述;1b 级,单一 RCT(置信区间较窄);1c 级,全或无(未治疗前患者均死亡或部分死亡,治疗后仅部分死亡或全部生存);2a 级,同质性队列研究的系统综述;2b 级:单一队列研究(包括低质量 RCT 研究;随访率 < 80%);2c 级,“结局”研究,生态学研究;3a 级:同质性病例对照研究的系统综述;3b 级,单独的病例对照研究;4 级,病例系列研究(以及质量差的队列和病例对照研究);5 级,没有严格评价的专家意见,或完全基于生理学和基础医学的研究。

推荐建议则根据证据质量、一致性、临床意义、普遍性、适用性等将推荐意见分为 A 级(优秀)、B 级(良好)、C 级(满意)、D 级(差)4 级。其中 A 级推荐意见应来自于 I 级水平的证据,所有研究结论一致,临床意义大,证据研究的样本人群与目标人群吻合,因此该推荐意见可直接应用于各医疗行为中;而 B、C 级推荐意见则在上述各方面存在问题,其适用性受到不同限制;D 级推荐意见无法应用于医疗行为。

2 推荐意见

2.1 腹腔内、腹膜后等腔隙及浅表切口泡沫材料的选择

推荐意见 1:腹腔内、腹膜后等腔隙使用聚乙烯醇的泡沫材料;浅表切口及缝合切口外使用聚氨酯或聚乙烯醇的泡沫材料^[10](推荐等级:C 级)。

VSD 技术需要的材料和设备包括泡沫材料、引流管、透性粘贴薄膜及负压源。其中多孔隙海绵样泡沫材料与创面等组织接触,孔隙之间相互联通,材料有两种:(1)聚乙烯醇,泡沫材料孔隙较小,直径 0.06~0.27 mm,抗张力强度大(522.4 kPa),不易断裂;(2)聚氨酯^[11-15],泡沫材料孔隙较大,直径 0.4~0.6 mm,肉芽易长入,抗张力强度低(111.1 kPa),容易断裂,有观察到聚氨酯泡沫碎片在伤口内滞留影响愈合的情况^[16]。

使用时将半透膜覆盖于泡沫材料表面,负压形成后将泡沫材料与周围组织固定形成一个密闭的整体^[17-18]。考虑到负压对肠道血供等的影响,与四肢应用 VSD 相比,腹部应用 VSD 技术时负压值通常较低,切口外皮肤、腹膜外创面或体腔应用时为 -300~-125 mmHg^[19](1 mmHg=0.133 kPa),腹腔暂时性关闭、腹腔内应用为 -175~-50 mmHg^[20-31],虽然没有高级别的循证医学证据,但对于有肠道修补或吻合的患者采用较低的负压值,如 -80~-50 mmHg^[23]。

2.2 VSD 技术用于腹部切口 I 期缝合的感染预防

推荐意见 2:在高感染风险的 I 期缝合腹部切口,建议应用预防性 VSD(PVSD)技术,有助于降低手术部位感染(SSI)发生率(推荐等级:B 级)。

共纳入 35 项研究,其中 6 项 RCTs 研究^[32-37],29 项观察性研究^[38-66]。

2016 年,世界卫生组织(WHO)在《Lancet Infectious Disease》杂志发布基于循证医学证据的术中和术后预防 SSI 措施,提出预防性 NPWT(pNPWT)可在高感染风险的 I 期缝合切口中应用(条件推荐,低质量)^[67]。共复习了 20 篇文献,包括 6 项 RCTs 研究和 14 项观察性研究,与传统伤口敷料相比,pNPWT 可降低闭合伤口发生 SSI 的风险。不同术式亚组分析,对腹部和心脏手术应用 pVSD 技术可降低手术切口 SSI 风险,但对骨科或创伤外科 SSI 无影响。不同级别切口亚组分析,pVSD 技术在降低清洁-污染、清洁切口 SSI 发生率方面差异有统计学意义。Chopra 等^[68]分析评估闭合切口 VSD 技术治疗和标准敷料在高危患者腹部切口关闭后的效果,829 例腹壁手术(260 例闭合切口 VSD 技术和 569 例标准敷料),结果显示与标准包扎相比,闭合切口负压治疗节省了 1 546.52 美元,认为当 SSI 发生率 > 16.39% 时,闭合切口 VSD 技术是一种经济有效的方法。2017 年发表的 1 篇国际多学科专家共识复习了 2000—2015 年的 100 篇文献,支持对 SSI 的高危患者缝合切口应用 VSD 技术,称为关闭切口

负压治疗,与传统敷料相比,可以降低 SSI 发生率^[69]。

关于不同手术类型亚组分析,有研究表明,pVSD 技术可以降低腹壁重建手术切口 SSI 发生率^[62-64,66]。但另有研究表明,pVSD 技术对降低 SSI 发生率无影响^[60]。pVSD 技术可以降低结直肠手术 SSI 发生率^[38-43],也可以降低胰十二指肠切除术 SSI 发生率^[60]。pVSD 技术对降低溃疡性结肠炎回肠造口还纳术 SSI 发生率无影响^[32]。腹部多种手术的 RCTs 有 6 项,其中 3 项 RCTs 研究表明 pVSD 可以降低 SSI 发生率^[32,35-36]。3 项研究提示不能降低 SSI 发生率^[33-34,37]。pVSD 技术可以降低儿科污染手术、妇科恶性肿瘤手术、剖宫产手术、肝移植手术等腹部外科手术切口 SSI 发生率^[44-45,49-50,52,57,59,65]。pVSD 技术可以减轻或减少术后疼痛和麻醉药的使用,虽然 SSI 发生率有所降低,但差异无统计学意义^[34]。

关于不同污染程度的切口亚组研究结果表明,pVSD 技术可以降低污染切口 SSI 发生率^[65]。但有研究表明,pVSD 技术对降低 SSI 发生率无影响^[61]。pVSD 技术可以降低清洁-污染切口 SSI 发生率^[38-41,43-45,60,62-64,66,70]。有研究表明,pVSD 技术可以降低切口 SSI 发生率^[34-36],但也有研究表明 pVSD 技术对降低 SSI 发生率无影响^[32-33,37]。

SSI 的高风险因素包括周围软组织损伤导致血管障碍、出血或血肿、有坏死组织、术中污染、手术时间长,以及肥胖、糖尿病和吸烟等^[67,69]。

2.3 VSD 技术用于严重污染/感染的腹部手术部位

推荐意见 3:严重污染/感染的腹部手术部位应用 VSD 技术,可以预防/治疗感染,缩短切口 II 期缝合的时间,缩短住院时间(推荐等级:B 级)。

共纳入 26 项研究,其中 3 项 RCTs 研究^[20,71-72],23 项观察性研究和个案系列研究^[26,50,64,71-90]。

1 项纳入 81 例腹部切口严重污染患者的 RCT 研究中,27 例 I 期关闭,29 例延迟关闭,25 例应用 VSD 技术,切口感染率分别为 37%、17% 和 0^[20]。2 项 VSD 技术用于腹壁疝无张力修补术后早期深部切口感染的观察性研究,共 33 例,切口拆线 VSD 技术治疗,9 例取出补片,24 例未取出补片,均于 4 周内愈合^[26,64]。

严重污染/感染的腹部手术部位应用 VSD 技术效果和可行性分析结果表明,腹腔内严重感染开放腹腔后 VSD 技术是安全的,能够提高患者的生存质量^[20]和减轻患者的全身炎症反应^[72]。但 VSD 技术

并不能加速脓液的引流和降低全身炎症反应标记物^[71]。

针对不同病因引起的腹膜后间隙感染应用 VSD 技术的多项观察性研究结果表明,VSD 技术能够早期控制局部感染,保持脓腔清洁,促进脓腔缩小,缩短愈合时间,减少局部并发症^[73-75],预防肝叶切除术后膈下感染^[76]。VSD 技术可有效降低腹腔严重感染患者的病死率,但并不能减轻全身的细菌负担,也不能预防院内获得性感染的发生率^[77]。腹部严重感染时应用 VSD 技术能够引流脓液,促进脓腔缩小,使创面肉芽新鲜,避免残余脓肿形成^[78-79]。

关于腹部手术部位留置 VSD 技术的作用机制,3 项观察性研究表明,应用 VSD 技术通过主动吸引引流彻底^[50,80-81]。此外,VSD 技术扩大了引流面积及引流范围,不易堵塞,加速组织消肿,更能有效地消灭死腔^[91]。其可能机制:(1)促进血液循环,减轻组织水肿,抑制细菌繁殖,局部机械牵拉作用促进创面或创腔缩小^[82-84];(2)持续真空负压把水肿组织中水分及渗出、残余脓液主动吸引排除,诱导细胞增殖及基质合成,加速愈合^[91];(3)加速血液灌注,促进血管化,改善局部循环,负压可以间接降低局部水肿组织的静水压,减少渗出,加速水肿的消退^[85-88];(4)VSD 技术持续负压导致的缺氧状态可抑制细菌的增殖,清除定植细菌和细菌培养基^[89-90]。

应用 VSD 技术防治腹部 SSI 时,应注意泡沫材料位于脓肿低处或中央,于最近处做腹壁切口引出泡沫,防止局部出血及肉芽组织过度长入。以缝线将泡沫材料和引流管牢固固定,避免引流管侧孔露出海绵面而致肠壁局灶性坏死。一般 5~7 d 去除或更换泡沫材料;若超过 9 d,则颗粒状肉芽组织长入泡沫内,不利取出,易出血^[92]。

2.4 腹腔间隙综合征(ACS)中严重创伤、感染、肝移植、腹腔内压力增高等情况下,VSD 技术用于腹腔临时关闭

推荐意见 4:推荐 VSD 技术作为严重腹部创伤、感染及肝移植等情况行暂时性腹腔关闭(TAC)和 ACS 行腹腔扩容的首选方法(推荐等级:B 级)。

共纳入 20 项研究,其中 1 项 RCT 研究^[93],19 项回顾性研究^[33,49,53,55-56,65,68,94-105]。

对于严重腹部创伤或腹腔内严重感染患者,完成出血和污染控制等腹腔内操作后,采取传统腹壁确定性缝合的腹腔关闭技术,可能会导致非计划二次手术、ACS、严重腹腔内感染和多脏器功能衰竭等

严重后果,失败率高。对此类患者需要行 TAC,可显著扩大腹腔容积而降低腹腔压力,避免腹腔内液体外渗,重建腹壁屏障保护腹腔内脏器、避免感染,降低胃肠道痿的发生率。TAC 可用于如下情形:(1)腹膜炎、坏死性筋膜炎、化脓性腹部感染等;(2)严重腹部创伤、损害控制性剖腹、腹壁毁损等;(3)肠系膜缺血,各种原因导致肠管循环难以确定时;(4)原发性、继发性腹腔高压症或 ACS 时;(5)肝移植时。理想状态下,TAC 应能使腹腔处于密闭状态,能保护腹腔内脏器,避免外源性污染或机械性损伤;引流腹腔内渗出;扩大腹腔容积以降低腹腔内压力,预防或治疗 ACS;保护筋膜的完整性,以便于日后的确定性腹腔关闭。有多种 TAC 方式可供选择,包括单纯皮肤关闭(巾钳夹闭或缝合)、塑料等材料与皮肤缝合、人工补片等与筋膜层缝合及 VSD 技术辅助关闭等。

应用 VSD 技术辅助的 TAC 已经成为主流的方法。VSD 技术关闭系统装置能满足理想的 TAC 的大部分要求。手术方法是完成腹腔内操作后,将大网膜置于切口下覆盖肠道,衬以薄膜有助于避免肠管与腹壁之间的粘连,VSD 技术泡沫材料与腹壁筋膜层或皮肤层缝合关闭腹部切口。贴膜覆盖整个创面,保持密封环境。引流管接负压吸引器,并调节压力 $-11 \sim -8$ mmHg,一般可以持续引流 $5 \sim 7$ d^[98]。

负压引流避免渗出液和炎症介质在腹腔内的聚集,持续负压引流保证及时将富含消化液的腹腔内液体转移到体外,减轻全身的毒素反应,并为受损胰腺的恢复创造一个良好的局部环境;最大限度降低有害液体对肠管和腹壁组织的腐蚀;方便行胰腺炎坏死组织清创;预防或减轻腹壁筋膜组织的哆开,单独或联合筋膜持续牵引,显著提高筋膜延迟闭合率,减少腹壁疝的发生;减少院内创面感染机会,方便护理^[33,53,99]。

VSD 技术在腹腔开放时间、换药次数、再探查率、腹部切口成功闭合率和肠空气痿方面都优于其他 TAC 方法^[68]。腹腔感染和腹腔高压术后应用 VSD 技术能够缩短患者的恢复时间,提高关腹成功率^[100]。肝移植术后应用 VSD 技术的研究显示,早期筋膜关闭中位时间达到 5.5 d($1 \sim 12$ d)^[56],还可以降低肝移植 TAC 患者并发症发生率和病死率^[49,56,101]。对于胰腺炎或多发伤导致的 ACS,应用 VSD 技术可以有效降低腹内压^[55]。对于急性胰腺炎而行开放腹腔的患者,应用 VSD 技术时有助于吸出腹腔内大量渗出,促进感染控制^[65]。

当全身情况好转后,腹腔内炎症水肿消退, $1 \sim 2$ 周内腹腔内感染控制,肠道水肿吸收,腹腔内压力 < 12 mmHg,则直接关腹;如果 $1 \sim 2$ 周后腹腔内压力仍 > 12 mmHg 或腹壁缺损等,待泡沫材料下肉芽组织增生后植皮,封闭创面,形成计划性腹疝, $6 \sim 12$ 个月后行确定性腹壁重建^[102-103]。应用 VSD 技术可以提高 I 期筋膜层关闭率至 $70\% \sim 90\%$ ^[94]。开放腹腔早期筋膜层关闭率由高到低依次为 VSD 技术加主动腹壁收拢、单独应用 VSD 技术、负压包和 Bogota 袋,分别为 74.6% 、 48% 、 35% 和 27% ^[21]。对于严重腹腔感染患者,应用 VSD 技术辅助开放腹腔具有更高的早期筋膜层关闭率,能够缩短 ICU 住院时间,降低病死率和相关并发症发生率^[104]。如果不能早期关腹,可能会带来一系列并发症,包括肠空气痿、腹腔感染、腹腔出血、腹壁疝等,其中最为复杂的是肠空气痿,发生率为 $5\% \sim 75\%$ ^[105]。不同 TAC 术后并发症发生率不同。VSD 技术辅助的 TAC 不会引起肠痿^[93]。而与 Bogota 袋和 Barker 技术相比,VSD 技术能减少并发症,降低感染率^[106]。

2.5 VSD 技术用于腹腔器官炎症、损伤或术后引流

推荐意见 5: 肝脏、胆道、胰腺、十二指肠等腹腔内脏器炎症、损伤、手术后应用 VSD 技术利于充分引流,预防和控制感染,促进愈合(推荐等级: C 级)。

VSD 技术用于腹腔内脏器损伤、手术或炎症治疗的文献较少,共纳入 11 项研究,包括 1 项 RCT 研究^[107],10 项观察性研究^[46-47,49,53,71,76,81,92,108-109]。

行坏死组织清除术和 VSD 技术引流的重症胰腺炎患者粒细胞膜流动性升高,生存率增加^[107]。1 项观察性研究报道了腹腔镜下应用 VSD 技术治疗重症胰腺炎 8 例的效果,切开胃结肠韧带将 $4 \text{ cm} \times 15 \text{ cm}$ 的泡沫材料置于胰腺表面小网膜囊内,术后更换泡沫材料 $4 \sim 7$ 次, 48 h 内平均引流 600 mL/d ,以后逐日减少,显著提高了治愈率^[76]。

与常规分期肝切除术相比,胆囊癌伴肝转移行联合肝脏分割和门静脉结扎的分期肝切除术中,在劈开的肝叶间置入泡沫材料应用 VSD 技术,剩余肝体积增加到原来 117% (以左侧增加明显),有助于促进患者伤口愈合^[47]。肝移植手术时联合 VSD 技术,可以降低伤口感染的发生率^[49]。同时,VSD 技术对胆总管、十二指肠和胰腺联合部分严重损伤具有良好的疗效,可减少并发症,降低感染率^[46,53,81],且能将 VSD 技术引流胰液安全有效地经空肠造瘘管回输入胃肠道内^[49]。重症胰腺炎或胰

腺损伤,虽然应用 VSD 技术可提高引流效率,对于没有发生自身消化的胰腺炎或胰腺损伤早期效果较好,而对于已经发生自身消化的胰腺炎或胰腺损伤患者,絮状坏死组织常堵塞泡沫,故需反复更换泡沫。另外,结肠由于黏液或粪便常导致泡沫材料堵塞,对于结肠损伤后瘘并不适合应用 VSD 技术^[109]。腹腔内放置应遵循取最短途径引出体外的原则,根据需要将泡沫材料修剪成合适的长宽度,至少保留 1 cm 材料在体外便于观察负压效果^[71]。为防止损伤肠道,应避免或减少泡沫材料与肠壁缝合处的接触,可靠的方法是剪短泡沫材料使其距离吻合口 1 cm 左右,或者在泡沫与肠管间固定间置大网膜^[108]。应密切观察负压和引流效果,如外露于体表的泡沫材料的弹性和塌陷状态。泡沫材料有效引流时间为 4~7 d,视引流物的性状可缩短或延长,如果发生泡沫材料堵塞应及时更换,尤其是重症胰腺炎时。腹腔内使用不建议冲洗,原因是冲洗时与引流并非同步,泡沫或导管堵塞所致的引流失效几乎不可能立即发现,堵塞时冲洗液可进入大腹腔,导致污染或感染扩散等^[107];治疗性使用引流区域局限、引流 48~72 h 后可以考虑冲洗;应确保引流管通畅,确保冲洗液体引流;冲洗液推荐生理盐水^[92]。

2.6 VSD 技术用于肠瘘和胰瘘的治疗

推荐意见 6: VSD 技术治疗肠外瘘、肠空气瘘和胰瘘,利于充分引流,控制感染,促进愈合(推荐等级: B 级)。

共纳入 22 项研究,其中 1 项 RCT 研究^[110],1 项系统性回顾研究^[111],20 项观察性研究^[80,93,110-127]。

肠瘘包括肠外瘘和肠空气瘘。肠瘘时,应用 VSD 技术作为瘘口或周围创面引流,可减少瘘口渗出液,利于控制继发感染,促进愈合。有关治疗性 VSD 技术和 pVSD 技术的亚组研究,2 项观察性研究表明,治疗性 VSD 技术可以最大限度减轻消化液对周围组织的腐蚀,避免继发感染,促进肠瘘闭合;建议选择聚乙烯醇白色泡沫材料,插管式负压吸引方式^[79,99]。应用聚氨酯黑色泡沫材料治疗急性肠瘘,直接密封全覆盖,吸盘式持续引流可以减少瘘口渗出液,促进创面愈合,利于肠瘘口闭合^[112,119-121,128]。慢性肠瘘可用 VSD 技术作为暂时性术前措施,用聚氨酯泡沫敷料隔离创面和肠瘘口可以提高瘘口的自然闭合率^[110]。与传统治疗方法比较,应用 VSD 技术能加快肠瘘愈合^[126],还可以控制瘘口渗出液,促进创面愈合,提高肠瘘修补术成功率^[111-118]。在高位

小肠瘘中应用 VSD 技术,最终所有患者肠瘘自行愈合,平均愈合时间为 45.3 d^[119]。应用 VSD 技术可成功促进十二指肠瘘的自行愈合,避免再次手术^[120]。通过 VSD 技术可成功治愈肠瘘^[121-122]。对于并发多处肠瘘的切口创面,应用 VSD 技术有助于肠瘘的控制并促进创面肉芽组织的增生,从而为确定性消化道重建及腹壁重建创造条件^[123]。但 VSD 技术的作用尚需要进一步研究来评估^[118]。应用 VSD 技术治疗肠外瘘的平均愈合率高^[111]。VSD 技术组在换药次数、愈合时间、治疗费用、体温恢复正常时间、肠内营养开始时间及继发相关并发症发生率等方面均较常规治疗组少(低)^[110]。采用自制的引流敷料填塞伤口或瘘口行封闭式持续负压吸引,可缩短肠外瘘伤口愈合时间,减少换药次数及缩短住院周期^[121]。

开放腹腔合并肠空气瘘的治疗非常棘手,有文献报道 VSD 技术治疗此类肠瘘极具优势^[93,127]。关于肠空气瘘时的隔离技术研究,有 5 项观察性研究表明,VAC 可以结合“环”/“筒仓”、轮胎环或奶嘴等方法隔离创面和肠瘘^[80,123-125]。由于结肠分泌黏液,可阻塞泡沫材料,导致引流无效,不建议使用 VSD 技术防治结肠瘘^[92]。

2.7 VSD 技术用于腹腔内、外脓肿的治疗

推荐意见 7: VSD 技术治疗腹腔内及腹膜外脓肿,利于充分引流,控制感染,促进愈合(推荐等级: C 级)。

共纳入 6 项观察性研究^[20,48,52,71,121,129]。

重症胰腺炎、胃肠道穿孔等导致的腹腔严重感染和腹腔脓肿开放腹腔后应用 VSD 技术是安全的,能够提高患者的生存质量^[20]。腹腔感染和腹腔高压术后 VSD 技术能够使患者的恢复时间缩短,关腹成功率提高^[52]。VSD 技术并不能加速脓液的引流和降低全身炎症反应标记物^[71]。

关于不同病因行 VSD 技术的研究结果显示,VSD 技术能够降低憩室炎穿孔后脓肿患者的病死率和永久性肠造口率^[121],降低胰腺脓肿的病死率和其他并发症发生率^[48]。对于继发性腹腔内脓肿,VSD 技术可以提高 I 期关腹率,但相关并发症发生率也升高,其他亚组是否获益需要进一步研究^[129]。

2.8 VSD 技术用于腹壁创面、创腔及缺损的治疗

推荐意见 8: VSD 技术治疗各种原因导致的腹壁创面、创腔及缺损,利于充分引流,控制感染,促进肉芽组织增生,促进创面愈合,缩短修复时间(推荐等级: C 级)。

共纳入 14 项研究,其中 12 项观察性研究^[48,61-63,66,112,129-133],2 项动物实验研究^[87-88]。

不同原因导致的腹壁缺损均可应用 VSD 技术。关于感染性因素导致的腹壁缺损使用负压引流,1 项腹壁抽脂导致的腹壁感染、坏死性筋膜炎、腹壁缺损的观察性研究表明,VSD 技术可以促进坏死组织引流,控制感染,促进肉芽形成,尽早进行缺损腹壁修复重建^[134]。对创伤导致的腹壁缺损应用 VSD 技术早期暂时关腹,可以有效保护暴露脏器,防止肠痿,减少创面及腹腔感染发生率,缩短术前准备时间,减少换药次数,有利于早期关闭腹腔^[87-88]。

腹壁缺损应用 VSD 技术的要点:(1)VSD 技术敷料可以直接覆盖于肠管表面,待肉芽形成后直接表面植皮^[133];(2)敷料不能直接与肠管接触,建议使用大网膜或合成材料(如硅胶片)覆盖于肠管上,再使用敷料覆盖负压引流,促进肉芽形成^[132];(3)敷料直接与肠管接触有导致肠痿的风险^[130]。关于腹壁缺损时负压压力,6 项观察性研究表明,负压应为 $-70 \sim -100 \text{ mmHg}$ ^[61-63,66,112,132]。

腹壁缺损修复重建时,无论使用合成材料(可吸收或不可吸收)修复缺损,还是皮瓣转移、植皮修复缺损,均可以结合应用 VSD 技术,可以提高成活率,缩短愈合时间^[48,129,131]。

2.9 VSD 技术与出血风险

推荐意见 9: VSD 技术泡沫材料应避免直接接触血管,建议间隔以自身组织或人工材料,并密切观察引流液性状(推荐等级:C 级)。

共纳入 8 项观察性研究^[135-142]。

虽然聚氨酯材料孔径较大,有损伤血管导致出血的可能,临床应用中却罕见 VSD 技术导致的血管源性并发症^[136-137],常见的出血往往来自于新鲜肉芽组织渗血,但是也不排除血管损伤后血管壁受侵蚀,发生迟发性出血的可能。应用 VSD 技术后出血主要发生在以下两种情况:(1)凝血功能障碍;(2)将 VSD 技术装置直接放置在暴露的心脏或血管上,尤其是吻合后的血管,抽吸可能会阻挡薄壁血管并导致出血^[137]。行血管近端吻合的患者予以 VSD 技术处理后发生多次出血^[138]。为避免这种情况,有学者建议在引流面和泡沫之间放置一人工材料屏障,不影响伤口的收缩和渗出液吸出^[139-140]。有胸骨切口应用 VSD 技术发生主动脉严重出血的个案,作者认为使用负压前要去掉伤口处散在的碎片^[141]。也有研究表明,VSD 技术装置堵塞也可能造成活动性出血^[135,142]。

2.10 VSD 技术与肠壁损伤风险

推荐意见 10: 应用 VSD 技术应警惕肠壁损伤的风险(推荐等级:B 级)。

共纳入 19 项腹部手术后应用 VSD 技术继发性肠道损伤的研究,其中 2 项 RCTs 研究^[143-144],17 项回顾性研究^[19,30,55,93,98,130,145-155]。

腹部手术后应用 VSD 技术治疗是否继发肠道损伤、增加肠痿发生率争议较大。目前越来越多的研究证实,应用 VSD 技术并不增加肠痿的发生率^[21,30,34,50,55,96,127,145,148,152,154,156]。

对于术前没有肠痿,应用 VSD 技术辅助 TAC 后,肠痿的发生率为 $1.6\% \sim 37\%$ ^[19,93,98,130,144-151]。前瞻性研究结果显示,应用 VSD 技术与可吸收网状补片固定于腹部筋膜层的 TAC 对肠痿发生率的影响差异均无统计学意义^[143-144]。5 项观察性研究中,Plaudis 等^[55]应用 VSD 技术治疗 ACS 和腹膜炎 22 例,其中 3 例发生小肠痿。Navsaria 等^[148]对 20 例腹部创伤患者术后应用 VSD 技术治疗,继发肠痿 1 例,肠坏死 1 例。Rao 等^[30]报告 29 例腹部手术患者术后应用 VSD 技术,6 例发生肠痿。而 Carlson 等^[152]对 578 例腹部手术患者的前瞻性观察性研究表明,应用 VSD 技术未增加肠痿及肠功能不全的发生率,并对该研究进行样本配对研究,共 187 对患者纳入分析,也得出同样结论。在包括 280 例腹部手术患者的观察性研究中,178 例应用 VSD 技术,并发胃肠缺血坏死 13 例、肠痿 7 例、肠梗阻 5 例,102 例采用负压包技术,分别为 3 例、4 例、0 例,两者差异无统计学意义^[153]。Kleif 等^[154]的研究表明,VSD 技术联用网片关腹可降低肠痿发生率。Mutafchiyski 等^[146]对 108 例因严重弥漫性腹膜炎行手术治疗的回顾性研究表明,应用 VSD 技术辅助 TAC 与网片暂时性关腹术组肠痿的发生率分别为 8% 和 19%,虽有降低趋势,但差异无统计学意义。VSD 技术的肠痿发生率较网片组高^[144,152]。

腹腔开放术中应用 VSD 技术不增加肠痿的发生率^[98,145,147,151,155]。对于腹部切口裂开和开放腹腔患者,VSD 技术是安全的,与肠痿发生率无直接相关^[155]。Fieger 等^[147]的 1 项回顾性研究中,82 例患者应用 VSD 技术后并发肠痿 16 例。同样,Björck 等^[98]的回顾性研究表明,腹部手术后应用 VSD 技术辅助与补片介导的筋膜牵引的 TAC 相比,两者肠痿的发生率差异也无统计学意义。Acosta 等^[145]的回顾性研究表明,腹部手术后应用 VSD 技术与改良 Barker 负压包相比,两者肠痿的发生率差异无统计

学意义。Mintziras 等^[151]的包括 43 例继发性腹膜炎患者术后应用 VSD 技术治疗[中位时间 12 d(3 ~ 88 d)]的回顾性研究中,16 例发生肠痿,该研究受试者工作特征(ROC)曲线分析表明,VSD 技术治疗时间 <13 d 可明显减少肠痿的发生。Montori 等^[157]的纳入 81 例开腹手术患者的双中心回顾性研究表明,肠道痿管的形成与 VSD 技术治疗并无相关性。

腹部 VSD 技术继发的肠道损伤的机制包括:(1)患者伴随的腹腔或全身病理变化^[145,151-152,155],包括腹膜炎、憩室炎^[85]、肠系膜缺血和动脉血乳酸 > 3.5 mmol/L^[152]、肠管供血不足、胰腺坏死等^[34,145,154]。(2)负压导致肠管血流量下降。负压值为 -125 mmHg 具有较好的引流效果且对小肠损伤较小^[8,17]。负压值为 -170 ~ -50 mmHg 可显著降低肠壁微血管血流量并与负压值呈正相关^[142]。-80 mmHg 是血流灌注和细胞生长的最佳负压值^[23-24],负压值设定尚需要进一步的深入研究。(3)泡沫材料的直接刺激,与 VSD 技术使用时间过长和更换过于频繁相关^[55]。剪短泡沫材料使其距离吻合口 1 cm 左右^[158-159],泡沫材料与肠管间置大网膜、银离子水胶体敷料、开孔敷料(如凡士林油纱、塑料薄膜或三升袋等),可减少肠管点状出血性损伤^[19,160]。

2.11 VSD 技术与腹膜粘连风险

推荐意见 11:应用 VSD 技术应关注腹膜粘连的发生。VSD 技术辅助的 TAC 时,在肠管和腹壁间置塑料薄膜等有助于减少粘连,提高筋膜早期关闭率(推荐等级:C 级)。

共纳入 9 项研究,其中 8 项为回顾性研究^[161-167],1 项为专家共识^[168]。

肠粘连为腹部外科手术后的常见并发症,发生率达 90%^[169-173]。腹膜粘连主要指肠管与肠管之间、肠管与腹膜之间、肠管与腹腔内脏器之间发生的异常黏附^[174]。腹膜炎、机械损伤、组织缺血、异物置入等病理因素均可引起腹膜表面的损伤,导致腹膜粘连的发生^[175-182]。关于腹腔内应用 VSD 技术对腹膜粘连形成的影响尚无确定结论。Magalini 等^[120]发现,针对胃肠痿应用 VSD 技术加强引流可减少肠粘连的范围和程度,为后期手术提供便利。

ACS 等行开放腹腔手术时应用 VSD 技术辅助的 TAC 可有效降低腹腔内压,同时并不能避免粘连形成^[161-163]。随着腹腔开放时间延长,可导致肠粘连、筋膜层回缩,如果不能早期关闭腹壁,则需于肉芽组织上植皮覆盖,形成计划性腹疝^[162,164-167]。2016 年关于创伤后开放腹腔的处理国际专家共识

意见推荐在 VSD 技术与腹腔内脏器之间使用一层聚丙烯塑料薄膜,以减少肠粘连的发生,利于筋膜关闭,减少相关并发症的发生^[168]。

3 总结与说明

本指南适用于腹部高危感染切口、严重污染/感染及临时关闭腹腔等需要应用 VSD 技术的情况。本指南中的建议是根据现有临床研究结果及使用经验得出的,随着 VSD 技术的不断发展和进步,以及更多高质量临床研究证据的积累,目前的一些观点可能在不久的将来得到更新。因此,临床工作者在使用本指南的同时,还要综合考虑患者的病情来进行临床决策。

[专家组名单]李阳、李培源、张连阳、孙士锦、姚元章(陆军军医大学大坪医院,陆军特色医学中心创伤外科,全军战创伤中心,创伤、烧伤与复合伤国家重点实验室,重庆 400042);白祥军、李占飞、刘涛、杨帆(华中科技大学同济医学院附属同济医院,武汉 430000);霍景山(广东省佛山中医院 528000);何武兵(福建省立医院,福州 350000);欧阳军(新疆石河子大学第一医院 832000);彭磊(海南医学院附属第一医院,海口 570100);胡平(重庆市急救医疗中心 400015);朱延安(浙江省台州医院 317700);金平(余姚市人民医院 315400);邵启峰(郑州市第九人民医院 450000);王彦峰(武汉大学中南医院 430071);戴睿武(成都军区总医院,成都 610000);胡培阳(浙江省台州市天台人民医院 317200);陈海鸣(南昌大学附属第一医院 330000);王革非(南京军区总医院,南京 210000);王永高(浙江省中医院,杭州 310006);金红旭(沈阳军区总医院,沈阳 110000);朱长举(郑州大学第一附属医院 450000);张其庸(贵州医科大学附属医院,贵阳 550000);邵标(昆明市第一人民医院 650000);桑锡光(山东大学齐鲁医院,济南 250000);尹昌林(陆军军医大学西南医院,重庆 400038)

利益冲突 所有作者均声明不存在利益冲突

参 考 文 献

- [1] Redon H, Jost WH, Troques R. Closure under reduced atmospheric pressure of extensive wounds[J]. Mem Acad Chir (Paris), 1954, 80(12-14):394-396.
- [2] Mclean W. The role of closed wound negative pressure suction in radical surgical procedures of the head and neck[J]. Laryngoscope, 1964, 74:70-94.
- [3] Fox 4th JW, Golden GT, Rodeheaver G, et al. Nonoperative management of fingertip pulp amputation by occlusive dressings[J]. Am J Surg, 1977, 133:255-256.
- [4] Fleischmann W, Lang E, Russ M. Treatment of infection by vacuum sealing[J]. Unfallchirurg, 1997, 100(4):301-304.
- [5] Fleischmann W, Strecker W, Bombelli M, et al. Vacuum sealing as treatment of soft tissue damage in open fractures[J]. Unfallchirurg, 1993, 96(9):488-492.
- [6] 曾志强, 袁华德, 陶世明, 等. 应用医用泡沫负压封闭引流治

- 疗体表脓肿 29 例[J]. 岭南现代临床外科, 1998, 3(1):20-21.
- [7] Argenta LC, Morykwas MJ. Vacuum-assisted closure; a new method for wound control and treatment; clinical experience[J]. *Ann Plast Surg*, 1997, 38(6):563-576.
 - [8] Morykwas MJ, Argenta LC, Shelton-Brown EI, et al. Vacuum-assisted closure; a new method for wound control and treatment; animal studies and basic foundation[J]. *Ann Plast Surg*, 1997, 38(6):553-562.
 - [9] Phillips B, Ball C, Badenoch D, et al. Oxford centre for evidence-based medicine levels of evidence[EB/OL]. (2011-05-22) [2018-04-01]. <http://www2.cch.org.tw/ebm/le/CEBM-Levels-of-Evidence.pdf?crazycache=1>.
 - [10] Milleret V, Bittermann AG, Mayer D, et al. Analysis of effective interconnectivity of DegraPol-foams designed for negative pressure wound therapy[J]. *Materials*, 2009, 2(1):292-306. DOI:10.3390/ma2010292.
 - [11] Chattopadhyay DK, Raju KV. Structural engineering of polyurethane coatings for high performance applications[J]. *Prog Polym Sci*, 2007, 32(3):352-418. DOI:10.1016/j.progpolymsci.2006.05.003.
 - [12] Meng Q, Hu J, Liu B, et al. A low-temperature thermoplastic anti-bacterial medical orthotic material made of shape memory polyurethane Ionomer; Influence of Ionic Group[J]. *J Biomater Sci Polym Ed*, 2009, 20(2):199-218. DOI:10.1163/156856209X404497.
 - [13] Versatile AA. Comfortable Polyvinyl Alcohol (PVA) Dressing for Use with V. A. C.® Therapy[EB/OL]. (2016-10-22) [2017-02-01]. <http://www.acelity.com/products/vac-therapy-dressings-accessories-white-foam-dressing>.
 - [14] Dai L, Yu S. Effect of degree of saponification on structural and property change of poly(Vinyl alcohol) fibers[J]. *Polym Adv Technol*, 2010, 14(7):449-457. DOI:10.1002/pat.351.
 - [15] Cole PA, Bhandari M. What's new in orthopaedic trauma[J]. *J Bone Joint Surg Am*, 2004, 86-A(12):2782-2795. DOI:10.2106/JBJS.G.01070.
 - [16] Ranjeetesh K, Singh RN, Singh BN. Comparative prospective study of proximal femoral nail and dynamic hip screw in treatment of intertrochanteric fracture femur[J]. *J Clin Orthop Traumatol*, 2012, 3(1):28-36.
 - [17] Pan Y, Zeng Q, Wang K. Application of negative pressure wound therapy with different negative pressures to open abdominal wound repair[J]. *Practical J Clin Med*, 2015, 12(2):44-46.
 - [18] 张连阳. 重视负压封闭引流在腹部外科中的应用[J]. 创伤外科杂志, 2012, 14(5):389-391. DOI:1009-4237(2012)05-0389-03.
 - [19] Heller L, Levin SL, Butler CE. Management of abdominal wound dehiscence using vacuum assisted closure in patients with compromised healing[J]. *Am J Surg*, 2006, 191(2):165-172. DOI:10.1016/j.amjsurg.2005.09.003.
 - [20] Wondberg D, Larusson HJ, Metzger U, et al. Treatment of the open abdomen with the commercially available vacuum-assisted closure system in patients with abdominal sepsis[J]. *World J Surg*, 2008, 32(12):2724-2729. DOI:10.1007/s00268-008-9762-y.
 - [21] Bruhin A, Ferreira F, Chariker M, et al. Systematic review and evidence based recommendations for the use of negative pressure wound therapy in the open abdomen[J]. *Int J Surg*, 2014, 12(10):1105-1114. DOI:10.1016/j.ijssu.2014.08.396.
 - [22] Suliburk JW, Ware DN, Zsolt B, et al. Vacuum-assisted wound closure achieves early fascial closure of open abdomens after severe trauma[J]. *J Trauma*, 2003, 55(6):1155-1160. DOI:10.1097/01.TA.0000100218.03754.6A.
 - [23] Ola B, Richard I, Malin M. Wound edge microvascular blood flow during negative-pressure wound therapy: examining the effects of pressures from -10 to -175 mmHg[J]. *Plast Reconstr Surg*, 2010, 125(2):502-509. DOI:10.1097/prs.0b013e3181c82e1f.
 - [24] Nease C. Using low pressure, NPWT for wound preparation & the management of split-thickness skin grafts in 3 patients with complex wound[J]. *Ostomy Wound Manage*, 2009, 55(6):32-42.
 - [25] 杨越涛, 宋承俊, 马柏强, 等. 腹腔扩容术 + VSD 治疗腹腔高压/腹腔间隙综合征[J]. 创伤外科杂志, 2016, 18(8):455-457. DOI:10.3969/j.issn.1009-4237.2016.08.003.
 - [26] 余洪涛. 负压封闭引流技术在腹外疝修补术后早期切口感染中临床应用[J/CD]. 中华疝和腹壁外科杂志:电子版, 2015, 9:337-339. DOI:10.3877/cma.j.issn.1674-392X.2015.04.016.
 - [27] 杜建伟, 李跃林. 暂时性腹腔关闭技术在严重腹腔感染中的临床效果观察[J]. 临床与转化医学, 2015, 5(1):52-53.
 - [28] Chuo CB, Thomas SS. Absorbable mesh and topical negative pressure therapy for closure of abdominal dehiscence with exposed bowel[J]. *J Plast Reconstr Aesthet Surg*, 2008, 61(11):1378-1381. DOI:10.1016/j.bjps.2007.04.012.
 - [29] Caviggioli F, Klinger FM, Lisa A, et al. Matching biological mesh and negative pressure wound therapy in reconstructing an open abdomen defect[J]. *Case Rep Med*, 2014, 235930(10):19. DOI:10.1155/2014/235930.
 - [30] Rao M, Burke D, Finan PJ, et al. The use of vacuum-assisted closure of abdominal wounds; a word of caution[J]. *Colorectal Dis*, 2007, 9(3):266-268. DOI:10.1111/j.1463-1318.2006.01154.x.
 - [31] Orgill DP, Bayer LR. Update on negative-pressure wound therapy[J]. *Plast Reconstr Surg*, 2011, 127(S1):105S-115S. DOI:10.1097/PRS.0b013e318200a427.
 - [32] Uchino M, Hirose K, Bando T, et al. Randomized controlled trial of prophylactic negative-pressure wound therapy at ostomy closure for the prevention of delayed wound healing and surgical site infection in patients with ulcerative colitis[J]. *Dig Surg*, 2016, 33(6):449-454. DOI:10.1159/000446550.
 - [33] Shen P, Blackham AU, Lewis S, et al. Phase II randomized trial of negative-pressure wound therapy to decrease surgical site infection in patients undergoing laparotomy for gastrointestinal, pancreatic, and peritoneal surface malignancies[J]. *J Am Coll Surg*, 2017, 224(4):726-737. DOI:10.1016/j.jamcollsurg.

2016. 12. 028.
- [34] Gunatilake RP, Swamy GK, Brancazio LR, et al. Closed-incision negative-pressure therapy in obese patients undergoing cesarean delivery: a randomized controlled trial [J]. *AJP Rep*, 2017, 7(3):e151-e157. DOI:10.1055/s-0037-1603956.
 - [35] O'Leary DP, Peirce C, Anglim B, et al. Prophylactic negative pressure dressing use in closed laparotomy wounds following abdominal operations: a randomized, controlled, open-label trial; the P. I. C. O. Trial [J]. *Ann Surg*, 2017, 265(6):1082-1086. DOI:10.1097/SLA.0000000000002098.
 - [36] Li PY, Yang D, Liu D, et al. Reducing surgical site infection with negative-pressure wound therapy after open abdominal surgery: a prospective randomized controlled study [J]. *Scand J Surg*, 2017, 106(3):189-195. DOI:10.1177/1457496916668681.
 - [37] Masden D, Goldstein J, Endara M, et al. Negative pressure wound therapy for at-risk surgical closures in patients with multiple comorbidities: a prospective randomized controlled study [J]. *Ann Surg*, 2012, 255(6):1043-1047. DOI: 10.1097/SLA.0b013e3182501bae.
 - [38] Selvaggi F, Pellino G, Sciaudone G, et al. New advances in negative pressure wound therapy (NPWT) for surgical wounds of patients affected with Crohn's disease [J]. *Surg Technol Int*, 2014, 24(1):83-89.
 - [39] Allen G, Blackham AU, Farrah JP, et al. Prevention of surgical site infections in high-risk patients with laparotomy incisions using negative-pressure therapy [J]. *Am J Surg*, 2013, 205(6):647-654. DOI:10.1016/j.ajom.2013.07.009.
 - [40] Bonds AM, Novick TK, Dietert JB, et al. Incisional negative pressure wound therapy significantly reduces surgical site infection in open colorectal surgery [J]. *Dis Colon Rectum*, 2013, 56(12):1403-1408. DOI:10.1097/DCR.0b013e3182a39959.
 - [41] Chadi SA, Kidane B, Britto K, et al. Incisional negative pressure wound therapy decreases the frequency of postoperative perineal surgical site infections: a cohort study [J]. *Dis Colon Rectum*, 2014, 57(8):999-1006. DOI:10.1097/DCR.00000000000000161.
 - [42] Pellino G, Sciaudone G, Candilio G, et al. Effects of a new pocket device for negative pressure wound therapy on surgical wounds of patients affected with Crohn's disease: a pilot trial [J]. *Surg Innov*, 2014, 21(2):204-212. DOI:10.1016/j.ijssu.2014.08.378.
 - [43] Zaidi A, El-Masry S. Closed-incision negative-pressure therapy in high-risk general surgery patients following laparotomy: a retrospective study [J]. *Colorectal Dis*, 2017, 19(3):283-287. DOI:10.1111/codi.13458.
 - [44] Lynam S, Mark KS, Temkin SM. Primary placement of incisional negative pressure wound therapy at time of laparotomy for gynecologic malignancies [J]. *Int J Gynecol Cancer*, 2016, 26(8):1525-1529. DOI:10.1097/IGC.0000000000000792.
 - [45] Anglim B, O'Connor H, Daly S. PrevenaTM, negative pressure wound therapy applied to closed Pfannenstiel incisions at time of caesarean section in patients deemed at high risk for wound infection [J]. *J Obstet Gynaecol*, 2015, 35(3):255-258. DOI:10.3109/01443615.2014.958442.
 - [46] 霍景山, 陈务民, 吴日钊, 等. 腹腔内应用负压封闭引流治疗严重胆胰结合部损伤 [J]. *创伤外科杂志*, 2017, 19(1):17-21. DOI:10.3969/j.issn.1009-4237.2017.01.005.
 - [47] Zhai B, Jin X, Wang R, et al. Applying negative pressure wound therapy in associating liver partition and portal vein ligation for staged hepatectomy: A case report [J]. *Exp Ther Med*, 2017, 14(1):642-646. DOI:10.3892/etm.2017.4566.
 - [48] Obolenskii VN, Ermolov AA, Oganessian KS, et al. Vacuum-assisted laparostomy in complex treatment of patient with peritonitis and internal biliary fistula [J]. *Khirurgiia*, 2013, (12):91-94.
 - [49] Dondossola D, Cavenago M, Piconi S, et al. Negative pressure wound treatment of infections caused by extensively drug-resistant gram-negative bacteria after liver transplantation: two case reports [J]. *Transplant Proc*, 2015, 47(7):2145-2149. DOI:10.1016/j.transproceed.2014.11.078.
 - [50] Fitzgerald JE, Gupta S, Masterson S, et al. Laparostomy management using the ABThera open abdomen negative pressure therapy system in a grade IV open abdomen secondary to acute pancreatitis [J]. *Int Wound J*, 2013, 10(2):138-144. DOI: 10.1111/j.1742-481X.2012.00953.x.
 - [51] Zanusi G, Boetto R, D'Amico F, et al. A novel approach to severe acute pancreatitis in sequential liver-kidney transplantation: the first report on the application of VAC therapy [J]. *Transpl Int*, 2011, 24(3):1432-2277. DOI:10.1111/j.1432-2277.2010.01198.x.
 - [52] Ruiz-Lopez M, Carrasco Campos J, Sanchez Perez B, et al. Negative pressure therapy in wounds with enteric fistulas [J]. *Cir Esp*, 2009, 86(1):29-32. DOI:10.1016/j.ciresp.2009.01.029.
 - [53] 霍景山, 陈积圣, 陈务民, 等. 腹腔内负压封闭引流治疗严重胰腺十二指肠损伤:附 16 例报告 [J]. *中国普通外科杂志*, 2014, 23(3):343-347. DOI: 10.7659/j.issn.1005-6947.2014.03.016.
 - [54] Jannasch O, Tautenhahn J, Lippert H, et al. Temporary abdominal closure and early and late pathophysiological consequences of treating an open abdomen [J]. *Zentralbl Chir*, 2011, 136(6):575-584. DOI:10.1055/s-0031-1271347.
 - [55] Plaudis H, Rudzats A, Melberga L, et al. Abdominal negative-pressure therapy: a new method in countering abdominal compartment and peritonitis-prospective study and critical review of literature [J]. *Ann Intensive Care*, 2012, 20(2):2110-5820. DOI:10.1186/2110-5820-2-S1-S23.
 - [56] Hobeika C, Allard MA, Bucur PO, et al. Management of the open abdomen after liver transplantation [J]. *World J Surg*, 2017, 41(12):3199-3204. DOI:10.1007/s00268-017-4125-1.
 - [57] Kugler NW, Carver TW, Paul JS. Negative pressure therapy is effective in abdominal incision closure [J]. *J Surg Res*, 2016, 203(2):491-494. DOI:10.1016/j.jss.2016.04.032.
 - [58] Smallwood NR, Fleshman JW, Leeds SG, et al. The use of endoluminal vacuum (E-Vac) therapy in the management of upper gastrointestinal leaks and perforations [J]. *Surg Endosc*, 2016,

- 30(6):2473-2480. DOI:10.1007/s00464-015-4501-6.
- [59] Lozano-Balderas G, Ruiz-Velasco-Santacruz A, Diaz-Elizondo JA, et al. Surgical site infection rate drops to 0% using a vacuum-assisted closure in contaminated/dirty infected laparotomy wounds[J]. *Am Surg*, 2017, 83(5):512-514.
- [60] Burkhart RA, Javed AA, Ronnekleiv-Kelly S, et al. The use of negative pressure wound therapy to prevent post-operative surgical site infections following pancreaticoduodenectomy [J]. *HPB*, 2017, 19(9):825-831. DOI:10.1016/j.hpb.2017.05.004.
- [61] Pauli EM, Krpata DM, Novitsky YW, et al. Negative pressure therapy for high-risk abdominal wall reconstruction incisions[J]. *Surg Infect*, 2013, 14(3):270-274. DOI:10.1089/sur.2012.059.
- [62] de Vries FEE, Atema JJ, Lapid O, et al. Closed incision prophylactic negative pressure wound therapy in patients undergoing major complex abdominal wall repair [J]. *Hernia*, 2017, 21(4):583-589. DOI:10.1007/s10029-017-1620-0.
- [63] Gassman A, Mehta A, Bucholdz E, et al. Positive outcomes with negative pressure therapy over primarily closed large abdominal wall reconstruction reduces surgical site infection rates[J]. *Hernia*, 2015, 19(2):273-278. DOI:10.1007/s10029-014-1312-y.
- [64] Soares KC, Baltodano PA, Hicks CW, et al. Novel wound management system reduction of surgical site morbidity after ventral hernia repairs: a critical analysis[J]. *Am J Surg*, 2015, 209(2):324-332. DOI:10.1016/j.amjsurg.2014.06.022.
- [65] Chen B, Hao F, Yang Y, et al. Prophylactic vacuum sealing drainage (VSD) in the prevention of postoperative surgical site infections in pediatric patients with contaminated laparotomy incisions[J]. *Medicine (Baltimore)*, 2017, 96(13):0000000000006511.
- [66] Conde-Green A, Chung TL, Holton LH 3rd, et al. Incisional negative-pressure wound therapy versus conventional dressings following abdominal wall reconstruction: a comparative study[J]. *Ann Plast Surg*, 2013, 71(4):394-397.
- [67] Allegranzi B, Zayed B, Bischoff P, et al. New WHO recommendations on intraoperative and postoperative measures for surgical site infection prevention: an evidence-based global perspective[J]. *Lancet Infect Dis*, 2016, 16(12):e288-e303. DOI:10.1016/S1473-3099(16)30402-9.
- [68] Chopra K, Gowda AU, Morrow C, et al. The economic impact of closed-incision negative-pressure therapy in high-risk abdominal incisions: a cost-utility analysis[J]. *Plast Reconstr Surg*, 2016, 137(4):1284-1289. DOI:10.1097/PRS.0000000000002024.
- [69] Willy C, Agarwal A, Andersen CA, et al. Closed incision negative pressure therapy: international multidisciplinary consensus recommendations[J]. *Int Wound J*, 2017, 14(2):385-398. DOI:10.1111/iwj.12612.
- [70] Pellino G, Sciaudone G, Candilio G, et al. Preventive NPWT over closed incisions in general surgery: does age matter? [J]. *Int J Surg*, 2014, 12(2):S64-S68. DOI:10.1177/1553350613496906.
- [71] Kirkpatrick AW, Roberts DJ, Faris PD, et al. Active negative pressure peritoneal therapy after abbreviated laparotomy: the intraperitoneal vacuum randomized controlled trial[J]. *Ann Surg*, 2015, 262(1):38-46. DOI:10.1097/SLA.0000000000001095.
- [72] Roberts DJ, Jenne CN, Ball CG, et al. Efficacy and safety of active negative pressure peritoneal therapy for reducing the systemic inflammatory response after damage control laparotomy (the Intraperitoneal Vacuum Trial): study protocol for a randomized controlled trial[J]. *Trials*, 2013, 14(141):1745-6215. DOI:10.1186/1745-6215-14-141.
- [73] Giudicelli G, Rossetti A, Scarpa C, et al. Prognostic factors for enterocutaneous fistula in open abdomen treated with negative pressure wound therapy: a multicentre experience[J]. *J Gastrointest Surg*, 2017, 21(8):1328-1334. DOI:10.1007/s11605-017-3453-7.
- [74] Franchin M, Tozzi M, Soldini G, et al. A case of continuous negative pressure wound therapy for abdominal infected lymphocele after kidney transplantation [J]. *Case Rep Transplant*, 2014, 2014:742161. DOI:10.1155/2014/742161.
- [75] Durai R, Ng PC. Perirectal abscess following procedure for prolapsed haemorrhoids successfully managed with a combination of VAC sponge and Redivac systems[J]. *Tech Coloproctol*, 2009, 13(4):307-309. DOI:10.1007/s10151-009-0503-5.
- [76] 陶世明, 王彦峰, 袁华德, 等. 负压封闭引流预防肝切除术后膈下感染[J]. *肝胆外科杂志*, 2000, 8(2):133-134. DOI:10.3969/j.issn.1006-4761.2000.02.029.
- [77] Pliakos I, Michalopoulos N, Papavramidis TS, et al. The effect of vacuum-assisted closure in bacterial clearance of the infected abdomen[J]. *Surg Infect*, 2014, 15(1):18-23. DOI:10.1089/sur.2012.156.
- [78] Rudzka-Nowak A, Luczywek P, Gajos MJ, et al. Application of manuka honey and GENADYNE A4 negative pressure wound therapy system in a 55-year-old woman with extensive phlegmonous and necrotic lesions in the abdominal integuments and lumbar region after traumatic rupture of the colon[J]. *Med Sci Monit*, 2010, 16(11):CS138-CS142.
- [79] 王彦峰, 袁华德. 负压封闭引流技术在普通外科中的应用[J]. *中华普通外科杂志*, 2001, 16(3):192. DOI:10.3760/j.issn.1007-631X.2001.03.028.
- [80] Banasiewicz T, Borejsza-Wysocki M, Meissner W, et al. Vacuum-assisted closure therapy in patients with large postoperative wounds complicated by multiple fistulas [J]. *Wideochir Inne Tech Maloinwazyjne*, 2011, 6(3):155-163. DOI:10.5114/wiitm.2011.24694.
- [81] 霍景山, 陶世明, 曾志强, 等. 负压闭式引流在腹腔镜下胆道镜胆管取石、胆总管一期缝合中的应用[J]. *中国微创外科杂志*, 2007, 7(9):863-864. DOI:10.3969/j.issn.1009-6604.2007.09.015.
- [82] 王春喜, 卢怡, 王晓勇. 负压封闭引流促进创伤修复机制的研究进展[J]. *创伤外科杂志*, 2009, 11(2):184-185. DOI:10.3969/j.issn.1009-4237.2009.02.035.
- [83] Howe LM. Current concepts in negative pressure wound therapy[J]. *Vet Clin North Am Small Anim Pract*, 2015, 45(3):565-584. DOI:10.1016/j.cvsm.2015.01.005.

- [84] Mouës CM, Heule F, Hovius SE. A review of topical negative pressure therapy in wound healing: sufficient evidence? [J]. *Am J Surg*, 2011, 201(4):544-556. DOI:10.1016/j.amjsurg.2010.04.029.
- [85] Mennigen R, Senninger N, Laukoetter MG. Novel treatment options for perforations of the upper gastrointestinal tract: endoscopic vacuum therapy and over-the-scope clips[J]. *World J Gastroenterol*, 2014, 20(24):7767-7776. DOI:10.3748/wjg.v20.i24.7767.
- [86] Damiani G, Pinnarelli L, Sommella L, et al. Vacuum-assisted closure therapy for patients with infected sternal wounds: a meta-analysis of current evidence[J]. *J Plast Reconstr Aesthet Surg*, 2011, 64(9):1119-1123. DOI:10.1016/j.bjps.2010.11.022.
- [87] 师俊莉, 席文锦, 易成刚, 等. 封闭负压引流促进猪腹部爆炸伤创面愈合的实验研究[J]. *细胞与分子免疫学杂志*, 2014, 3(1):312-315.
- [88] 邵建川, 韩岩, 王宏坤, 等. 负压封闭引流技术治疗爆炸伤致猪全层腹壁缺损的实验研究[J]. *中国美容医学杂志*, 2011, 20(7):421-424. DOI:10.3969/j.issn.1008-6455.2011.07.033.
- [89] Weed T, Ratliff C, Drake DB. Quantifying bacterial bioburden during negative pressure wound therapy: does the wound VAC enhance bacterial clearance? [J]. *Ann Plast Surg*, 2004, 52(3):276-279.
- [90] Phillips PG, Birnby LM, Narendran A. Hypoxia induces capillary network formation in cultured bovine pulmonary microvessel endothelial cells[J]. *Am J Physiol*, 1995, 268(5 Pt 1):L789-L800. DOI:10.1152/ajplung.1995.268.5.L789.
- [91] Takei T, Mills I, Arai K, et al. Molecular basis for tissue expansion: clinical implications for the surgeon[J]. *Plast Reconstr Surg*, 1998, 102(1):247-258.
- [92] 张连阳. 腹部外科中的负压封闭引流现状及展望[J]. *创伤外科杂志*, 2016, 18(8):449-451. DOI:10.3969/j.issn.1009-4237.2016.08.001.
- [93] Richter S, Dold S, Doberauer JP, et al. Negative pressure wound therapy for the treatment of the open abdomen and incidence of enteral fistulas: a retrospective bicentre analysis[J]. *Gastroenterol Res Pract*, 2013, 2013:730829. DOI:10.1155/2013/730829.
- [94] Regner JL, Kobayashi L, Coimbra R. Surgical strategies for management of the open abdomen[J]. *World J Surg*, 2012, 36(3):497-510. DOI:10.1007/s00268-011-1203-7.
- [95] Kirkpatrick AW, Roberts DJ, De Waele J, et al. Intra-abdominal hypertension and the abdominal compartment syndrome: updated consensus definitions and clinical practice guidelines from the World Society of the Abdominal Compartment Syndrome[J]. *Intensive Care Med*, 2013, 39(7):1190-1206. DOI:10.1007/s00134-013-2906-z.
- [96] Cristaudo A, Jennings S, Gunnarsson R, et al. Complications and mortality associated with temporary abdominal closure techniques: a systematic re-view and meta-analysis[J]. *Am Surg*, 2017, 83(2):191-216.
- [97] Leppaniemi A, Johansson K, De Waele JJ. Abdominal compartment syndrome and acute pancreatitis[J]. *Acta Clin Belg*, 2007, 62(S1):131-135. DOI:10.1179/acb.2007.62.s1.016.
- [98] Björck M. Vacuum and mesh-mediated fascial traction for primary closure of open abdomen in critically ill surgical patients[J]. *Br J Surg*, 2012, 99(12):1732-1733. DOI:10.1002/bjs.8917.
- [99] 文金玲, 钟小晶, 刘香香. 胰十二指肠联合伤负压封闭引流的胰液经空肠造口管回输的护理[J]. *临床医学工程*, 2011, 18(6):943-944. DOI:10.3969/j.issn.1674-4659.2011.06.0943.
- [100] Perez D, Wildi S, Demartines N, et al. Prospective evaluation of vacuum-assisted closure in abdominal compartment syndrome and severe abdominal sepsis[J]. *J Am Coll Surg*, 2007, 205(4):586-592. DOI:10.1016/j.jamcollsurg.2007.05.015.
- [101] Assirati G, Serra V, Tarantino G, et al. Vacuum-assisted closure therapy in patients undergoing liver transplantation with necessity to maintain open abdomen[J]. *Transplant Proc*, 2016, 48(2):383-385. DOI:10.1016/j.transproceed.2015.12.037.
- [102] Anand RJ, Ivatury RR. Surgical management of intra-abdominal hypertension and abdominal compartment syndrome[J]. *Am Surg*, 2011, 77(1):S42-S45. DOI:10.1016/j.oraloncology.2011.06.086.
- [103] Tautenhahn J, Pross M, Kuhn R, et al. The use of v. a. C. — system in wound management for borderline indications[J]. *Zentralbl Chir*, 2004, 129 Suppl 1:S12. DOI:10.1055/s-2004-822604.
- [104] Sibaja P, Sanchez A, Villegas G, et al. Management of the open abdomen using negative pressure wound therapy with instillation in severe abdominal sepsis: A review of 48 cases in Hospital Mexico, Costa Rica[J]. *Int J Surg Case Rep*, 2017, 30:26-30. DOI:10.1016/j.ijscr.2016.11.024.
- [105] Riha GM, Kiraly LN, Diggs BS, et al. Management of the open abdomen during the global war on terror[J]. *JAMA Surg*, 2013, 148(1):59-64. DOI:10.1001/2013.jamasurg.4.
- [106] Ribeiro Junior MA, Barros EA, de Carvalho SM, et al. Open abdomen in gastrointestinal surgery: Which technique is the best for temporary closure during damage control? [J]. *World J Gastrointest Surg*, 2016, 8(8):590-597. DOI:10.4240/wjgs.v8.i8.590.
- [107] Miranda-Diaz AG, Hermosillo-Sandoval JM, Gutierrez-Martinez CA, et al. Effect of necrosectomy and vacuum-assisted closure (VAC) on mitochondrial function and oxidative stress markers in severe acute pancreatitis[J]. *Rev Esp Enferm Dig*, 2014, 106(8):505-514.
- [108] Sermoneta D, Di Mugno M, Spada PL, et al. Intra-abdominal vacuum-assisted closure (VAC) after necrosectomy for acute necrotizing pancreatitis: preliminary experience[J]. *Int Wound J*, 2010, 7(6):525-530. DOI:10.1111/j.1742-481X.2010.00727.x.
- [109] Olejnik J, Vokurka J, Vician M. Acute necrotizing pancreatitis: intra-abdominal vacuum sealing after necrosectomy[J]. *Hepatogastroenterology*, 2008, 55(82-83):315-318.

- [110] Bobkiewicz A, Walczak D, Smolinski S, et al. Management of enteroatmospheric fistula with negative pressure wound therapy in open abdomen treatment: a multicentre observational study[J]. *Int Wound J*, 2017, 14(1):255-264. DOI:10.1111/iwj.12597.
- [111] Misky A, Hotouras A, Ribas Y, et al. A systematic literature review on the use of vacuum assisted closure for enterocutaneous fistula[J]. *Colorectal Dis*, 2016, 18(9):846-851. DOI:10.1111/codi.13351.
- [112] de Weerd L, Kjaeve J, Aghajani E, et al. The sandwich design: a new method to close a high-output enterocutaneous fistula and an associated abdominal wall defect[J]. *Ann Plast Surg*, 2007, 58(5):580-583. DOI:10.1097/01.sap.0000237643.45125.8b.
- [113] Gunn LA, Follmar KE, Wong MS, et al. Management of enterocutaneous fistulas using negative-pressure dressings[J]. *Ann Plast Surg*, 2006, 57(6):621-625. DOI:10.1097/01.sap.0000228966.13979.1c.
- [114] Nienhuijs SW, Manupassu R, Strobbe LJ, et al. Can topical negative pressure be used to control complex enterocutaneous fistulae? [J]. *J Wound Care*, 2003, 12(9):343-345. DOI:10.12968/jowc.2003.12.9.26536.
- [115] Alvarez AA, Maxwell GL, Rodriguez GC. Vacuum-assisted closure for cutaneous gastrointestinal fistula management[J]. *Gynecol Oncol*, 2001, 80(3):413-416. DOI:10.1006/gyno.2000.6092.
- [116] Cro C, George KJ, Donnelly J, et al. Vacuum assisted closure system in the management of enterocutaneous fistulae[J]. *Postgrad Med J*, 2002, 78(920):364-365. DOI:10.1109/MEMB.2003.1195705.
- [117] Tavusbay C, Gene H, Cin N, et al. Use of a vacuum-assisted closure system for the management of enteroatmospheric fistulae[J]. *Surg Today*, 2015, 45(9):1102-1111. DOI:10.1007/s00595-014-1020-3.
- [118] Wainstein DE, Fernandez E, Gonzalez D, et al. Treatment of high-output enterocutaneous fistulas with a vacuum-compaction device. A ten-year experience[J]. *World J Surg*, 2008, 32(3):430-435. DOI:10.1007/s00268-007-9235-8.
- [119] 马丹, 陈江鸿, 杨桦. 应用负压封闭引流治疗高位小肠瘘[J]. *创伤外科杂志*, 2016, 18(8):458-460. DOI:10.3969/j.issn.1009-4237.2016.08.004.
- [120] Magalini S, Pepe G, Cozza V, et al. Negative pressure wound therapy (NPWT) in duodenal breakdown fistulas: negative pressure fistula therapy (NPFT)? [J]. *Eur Rev Med Pharmacol Sci*, 2017, 21(10):2452-2457.
- [121] Boulanger K, Lemaire V, Jacquemin D. Vacuum-assisted closure of enterocutaneous fistula[J]. *Acta Chir Belg*, 2007, 107(6):703-705. DOI:10.1080/00015458.2007.11680153.
- [122] Pepe G, Magalini S, Callari C, et al. Vacuum Assisted Closure (VAC) therapy™ as a swiss knife multi-tool for enteric fistula closure: tips and tricks: a pilot study[J]. *Eur Rev Med Pharmacol Sci*, 2014, 18(17):2527-2532.
- [123] Becker HP, Willms A, Schwab R. Small bowel fistulas and the open abdomen [J]. *Scand J Surg*, 2007, 96(4):263-271. DOI:10.1177/145749690709600402.
- [124] Verhaalen A, Watkins B, Brasel K. Techniques and cost effectiveness of enteroatmospheric fistula isolation [J]. *Wounds*, 2010, 22(8):212-217. DOI: 10.1016/j.wneu.2010.05.005.
- [125] Goverman J, Yelon JA, Platz JJ, et al. The "Fistula VAC," a technique for management of enterocutaneous fistulae arising within the open abdomen: report of 5 cases[J]. *J Trauma*, 2006, 60(2):428-431. DOI: 10.1097/01.ta.0000203588.66012.c4.
- [126] 沈伟, 张银超, 陶国, 等. 负压封闭引流治疗肠道皮肤瘘的临床应用[J]. *中国现代普通外科进展*, 2016, 19(9):707-710. DOI:10.3969/j.issn.1009-9905.2016.09.009.
- [127] Jagusik R, Walczak DA, Porzezynska J, et al. The use of negative pressure wound therapy (npwt) in the management of enteroatmospheric fistula — case report and literature review[J]. *Pol Przegl Chir*, 2015, 87(10):522-527. DOI:10.1515/pjs-2015-0098.
- [128] Stremitzer S, Dal Borgo A, Wild T, et al. Successful bridging treatment and healing of enteric fistulae by vacuum-assisted closure (VAC) therapy and targeted drainage in patients with open abdomen[J]. *Int J Colorectal Dis*, 2011, 26(5):661-666. DOI:10.1007/s00384-010-1126-z.
- [129] Schmelzle M, Alldinger I, Matthaei H, et al. Long-term vacuum-assisted closure in open abdomen due to secondary peritonitis: a retrospective evaluation of a selected group of patients[J]. *Dig Surg*, 2010, 27(4):272-278. DOI:10.1159/000314609.
- [130] Bertelsen CA, Fabricius R, Kleif J, et al. Outcome of negative-pressure wound therapy for open abdomen treatment after nontraumatic lower gastrointestinal surgery: analysis of factors affecting delayed fascial closure in 101 patients[J]. *World J Surg*, 2014, 38(4):774-781. DOI:10.1007/s00268-013-2360-7.
- [131] Kafka-Ritsch R, Birkfellner F, Perathoner A, et al. Damage control surgery with abdominal vacuum and delayed bowel reconstruction in patients with perforated diverticulitis Hinchey III/IV[J]. *J Gastrointest Surg*, 2012, 16(10):1915-1922. DOI: 10.1007/s00268-012-1586-0.
- [132] Aydin D, Paulsen IF, Bentzen VE, et al. Reconstruction of massive full-thickness abdominal wall defect: successful treatment with nonabsorbable mesh, negative pressure wound therapy, and split-skin grafting[J]. *Clin Case Rep*, 2016, 4(10):982-985. DOI:10.1002/ccr3.649.
- [133] 陈帆, 朱宏亮, 钱洪军, 等. 暂时性腹腔关闭与常规关腹技术治疗严重腹腔感染的临床对比[J]. *中国微创外科杂志*, 2015, 15(7):628-631. DOI: 10.3969/j.issn.1009-6604.2015.07.015.
- [134] Shin JS, Choi HJ. Application of a silicone sheet in negative-pressure wound therapy to treat an abdominal wall defect after necrotizing fasciitis[J]. *Arch Plast Surg*, 2017, 44(1):76-79. DOI:10.5999/aps.2017.44.1.76.
- [135] Jones GA, Butler J, Lieberman I, et al. Negative-pressure wound therapy in the treatment of complex postoperative spinal wound infections: complications and lessons learned using vacu-

- um-assisted closure[J]. *J Neurosurg Spine*, 2007, 6(5):407-411. DOI:10.3171/spi.2007.6.5.407.
- [136] Nollf MC, Meyer-Lindenberg A. Negative Pressure Wound Therapy (NPWT) in small animal medicine. Mechanisms of action, applications and indications[J]. *Tierarztl Prax Ausg K Kleintiere Heimtiere*, 2016, 44(1):26-37. DOI:10.15654/TPK-150957.
- [137] Martindell D. The safe use of negative-pressure wound therapy[J]. *Am J Nurs*, 2012, 112(6):59-63. DOI:10.1097/01.NAJ.0000415134.85429.9d.
- [138] Cheng HT, Hsu YC, Wu CI. Efficacy and safety of negative pressure wound therapy for Szilagyi grade III peripheral vascular graft infection[J]. *Interact Cardiovasc Thorac Surg*, 2014, 19(6):1048-1052. DOI:10.1093/icvts/ivu289.
- [139] Anesater E, Borgquist O, Torbrand C, et al. The use of a rigid disc to protect exposed structures in wounds treated with negative pressure wound therapy: effects on wound bed pressure and microvascular blood flow[J]. *Wound Repair Regen*, 2012, 20(4):611-616. DOI:10.1111/j.1742-481X.2011.00805.x.
- [140] Anesater E, Roupe KM, Robertsson P, et al. The influence on wound contraction and fluid evacuation of a rigid disc inserted to protect exposed organs during negative pressure wound therapy[J]. *Int Wound J*, 2011, 8(4):393-399. DOI:10.1111/j.1524-475X.2012.00801.x.
- [141] Kiessling AH, Lehmann A, Isgro F, et al. Tremendous bleeding complication after vacuum-assisted sternal closure[J]. *J Cardiothorac Surg*, 2011, 6(16):1749-8090. DOI:10.1186/1749-8090-6-16.
- [142] Schimp VL, Worley C, Brunello S, et al. Vacuum-assisted closure in the treatment of gynecologic oncology wound failures[J]. *Gynecol Oncol*, 2004, 92(2):586-591. DOI:10.1016/j.ygyno.2003.10.055.
- [143] Correa JC, Mejia DA, Duque N, et al. Managing the open abdomen: negative pressure closure versus mesh-mediated fascial traction closure: a randomized trial[J]. *Hernia*, 2016, 20(2):221-229. DOI:10.1007/s10029-016-1459-9.
- [144] Bee TK, Croce MA, Magnotti LJ, et al. Temporary abdominal closure techniques: a prospective randomized trial comparing polyglactin 910 mesh and vacuum-assisted closure[J]. *J Trauma*, 2008, 65(2):337-342. DOI:10.1097/TA.0b013e31817fa451.
- [145] Acosta S, Bjarnason T, Petersson U, et al. Multicentre prospective study of fascial closure rate after open abdomen with vacuum and mesh-mediated fascial traction[J]. *Br J Surg*, 2011, 98(5):735-743. DOI:10.1002/bjs.7383.
- [146] Mutaftchyski VM, Popivanov GI, Kjossev KT, et al. Open abdomen and VAC(R) in severe diffuse peritonitis[J]. *J R Army Med Corps*, 2016, 162(1):30-34. DOI:10.1136/jramc-2014-000386.
- [147] Fieger AJ, Schwatlo F, Mundel DF, et al. Abdominal vacuum therapy for the open abdomen-a retrospective analysis of 82 consecutive patients[J]. *Zentralbl Chir*, 2011, 136(1):56-60. DOI:10.1055/s-0030-1247376.
- [148] Navsaria P, Nicol A, Hudson D, et al. Negative pressure wound therapy management of the "open abdomen" following trauma: a prospective study and systematic review[J]. *World J Emerg Surg*, 2013, 8(1):1749-7922. DOI:10.1186/1749-7922-8-4.
- [149] Hougaard HT, Ellebaek M, Holst UT, et al. The open abdomen: temporary closure with a modified negative pressure therapy technique[J]. *Int Wound J*, 2014, 11(S1):13-16. DOI:10.1111/iwj.12281.
- [150] Kafka-Ritsch R, Zitt M, Schorn N, et al. Open abdomen treatment with dynamic sutures and topical negative pressure resulting in a high primary fascia closure rate[J]. *World J Surg*, 2012, 36(8):1765-1771. DOI:10.1007/s00268-012-1586-0.
- [151] Mintziras I, Miligkos M, Bartsch DK. High risk of fistula formation in vacuum-assisted closure therapy in patients with open abdomen due to secondary peritonitis-a retrospective analysis[J]. *Langenbecks Arch Surg*, 2016, 401(5):619-625. DOI:10.1007/s00423-016-1443-y.
- [152] Carlson GL, Patrick H, Amin AI, et al. Management of the open abdomen: a national study of clinical outcome and safety of negative pressure wound therapy[J]. *Ann Surg*, 2013, 257(6):1154-1159. DOI:10.1097/SLA.0b013e31828b8bc8.
- [153] Cheatham ML, Demetriades D, Fabian TC, et al. Prospective study examining clinical outcomes associated with a negative pressure wound therapy system and Barker's vacuum packing technique[J]. *World J Surg*, 2013, 37(9):2018-2030. DOI:10.1007/s00268-013-2080-z.
- [154] Kleif J, Fabricius R, Bertelsen CA, et al. Promising results after vacuum-assisted wound closure and mesh-mediated fascial traction[J]. *Dan Med J*, 2012, 59(9):A4495. DOI:10.1016/j.ijosm.2012.04.002.
- [155] Shaikh IA, Ballard-Wilson A, Yalamarthy S, et al. Use of topical negative pressure in assisted abdominal closure does not lead to high incidence of enteric fistulae[J]. *Colorectal Dis*, 2010, 12(9):931-934. DOI:10.1111/j.1463-1318.2009.01929.x.
- [156] Seternes A, Rekstad LC, Mo S, et al. Open abdomen treated with negative pressure wound therapy: indications, management and survival[J]. *World J Surg*, 2017, 41(1):152-161. DOI:10.1007/s00268-016-3694-8.
- [157] Montori G, Allievi N, Coccolini F, et al. Negative pressure wound therapy versus modified barker vacuum pack as temporary abdominal closure technique for open abdomen management: a four-year experience[J]. *BMC Surg*, 2017, 17(1):86. DOI:10.1186/s12893-017-0281-3.
- [158] Lindstedt S, Malmso M, Hansson J, et al. Macroscopic changes during negative pressure wound therapy of the open abdomen using conventional negative pressure wound therapy and NPWT with a protective disc over the intestines[J]. *BMC Surg*, 2011, 11:10. DOI:10.1186/1471-2482-11-10.
- [159] Lindstedt S, Malmso M, Hansson J, et al. Pressure transduction and fluid evacuation during conventional negative pressure wound therapy of the open abdomen and NPWT using a protective

- disc over the intestines[J]. *BMC Surg*, 2012, 12:4. DOI:10.1186/1471-2482-12-4.
- [160] Fansler RF, Taheri P, Cullinane C, et al. Polypropylene mesh closure of the complicated abdominal wound[J]. *Am J Surg*, 1995, 170(1):15-18. DOI:10.1016/S0002-9610(99)80244-X.
- [161] Fantus RJ, Mellett MM, Kirby JP. Use of controlled fascial tension and an adhesion preventing barrier to achieve delayed primary fascial closure in patients managed with an open abdomen[J]. *Am J Surg*, 2006, 192(2):243-247. DOI:10.1016/j.amjsurg.2005.11.013.
- [162] Barker DE, Kaufman HJ, Smith LA, et al. Vacuum pack technique of temporary abdominal closure: a 7-year experience with 112 patients[J]. *J Trauma*, 2000, 48(2):201-206. DOI:10.1097/00005373-200002000-00001.
- [163] Miller PR, Meredith JW, Johnson JC, et al. Prospective evaluation of vacuum-assisted fascial closure after open abdomen: planned ventral hernia rate is substantially reduced[J]. *Ann Surg*, 2004, 239(5):608-614. DOI:10.1007/s10353-004-0087-2.
- [164] Vidal MG, Ruiz Weisser J, Gonzalez F, et al. Incidence and clinical effects of intra-abdominal hypertension in critically ill patients[J]. *Crit Care Med*, 2008, 36(6):1823-1831. DOI:10.1097/CCM.0b013e31817c7a4d.
- [165] Raeburn CD, Moore EE, Biffl WL, et al. The abdominal compartment syndrome is a morbid complication of postinjury damage control surgery[J]. *Am J Surg*, 2001, 182(6):542-546. DOI:10.1016/S0002-9610(01)00821-2.
- [166] Cheatham ML, Safcsak K. Is the evolving management of intra-abdominal hypertension and abdominal compartment syndrome improving survival? [J]. *Crit Care Med*, 2010, 38(2):402-407. DOI:10.1007/s00268-013-2080-z.
- [167] Miller RS, Morris JA Jr, Diaz JJ Jr, et al. Complications after 344 damage-control open celiotomies[J]. *J Trauma*, 2005, 59(6):1365-1371. DOI:10.1097/01.ta.0000196004.49422.af.
- [168] Chiara O, Cimbanassi S, Biffl W, et al. International consensus conference on open abdomen in trauma[J]. *J Trauma Acute Care Surg*, 2016, 80(1):173-183. DOI:10.1097/TA.0000000000000882.
- [169] Ellis H. The clinical significance of adhesions: focus on intestinal obstruction[J]. *Eur J Surg Suppl*, 1997, 577:5-9. DOI:10.1016/S1010-7940(96)01002-0.
- [170] Ellis H. Medicolegal consequences of postoperative intra-abdominal adhesions[J]. *J R Soc Med*, 2001, 94(7):331-332. DOI:10.1016/j.ijsu.2009.04.004.
- [171] Duron JJ. Postoperative intraperitoneal adhesion pathophysiology[J]. *Colorectal Dis*, 2007, 2:14-24. DOI:10.1111/j.1463-1318.2007.01343.x.
- [172] Moris D, Chakedis J, Rahnemai-Azar AA, et al. Postoperative abdominal adhesions: clinical significance and advances in prevention and management[J]. *J Gastrointest Surg*, 2017, 21(10):1713-1722. DOI:10.1007/s11605-017-3488-9.
- [173] Boland GM, Weigel RJ. Formation and prevention of postoperative abdominal adhesions[J]. *J Surg Res*, 2006, 132(1):3-12. DOI:10.1016/j.jss.2005.12.002.
- [174] Hackethal A, Sick C, Szalay G, et al. Intra-abdominal adhesion formation: does surgical approach matter? Questionnaire survey of South Asian surgeons and literature review[J]. *J Obstet Gynaecol Res*, 2011, 37(10):1382-1390. DOI:10.1111/j.1447-0756.2011.01543.x.
- [175] Bruggmann D, Tchatchian G, Wallwiener M, et al. Intra-abdominal adhesions: definition, origin, significance in surgical practice, and treatment options[J]. *Dtsch Arztebl Int*, 2010, 107(44):769-775. DOI:10.3238/arztebl.2010.0769.
- [176] Beyene RT, Kavalukas SL, Barbul A. Intra-abdominal adhesions: Anatomy, physiology, pathophysiology, and treatment[J]. *Curr Probl Surg*, 2015, 52(7):271-319. DOI:10.1067/j.cpsurg.2015.05.001.
- [177] Maciver AH, McCall M, James Shapiro AM. Intra-abdominal adhesions: cellular mechanisms and strategies for prevention[J]. *Int J Surg*, 2011, 9(8):589-594. DOI:10.1016/j.ijsu.2011.08.008.
- [178] Thaler K, Mack JA, Zhao RH, et al. Expression of connective tissue growth factor in intra-abdominal adhesions[J]. *Dis Colon Rectum*, 2002, 45(11):1510-1519. DOI:10.1097/01.DCR.0000034135.54101.32.
- [179] Tokita Y, Yuzurihara M, Satoh K, et al. The cholinergic nervous system plays an important role in rat postoperative intestinal adhesion[J]. *Surgery*, 2008, 143(2):226-232. DOI:10.1016/j.surg.2007.07.017.
- [180] Arung W, Meurisse M, Detry O. Pathophysiology and prevention of postoperative peritoneal adhesions[J]. *World J Gastroenterol*, 2011, 17(41):4545-4553. DOI:10.3748/wjg.v17.i41.4545.
- [181] Holmdahl L, Eriksson E, al-Jabreen M, et al. Fibrinolysis in human peritoneum during operation[J]. *Surgery*, 1996, 119(6):701-705. DOI:10.1016/S0039-6060(96)80196-6.
- [182] Ivarsson ML, Bergstrom M, Eriksson E, et al. Tissue markers as predictors of postoperative adhesions[J]. *Br J Surg*, 1998, 85(11):1549-1554.

(收稿日期:2019-02-15)