

负压伤口疗法在糖尿病足创面治疗中的应用 全国专家共识(2021 版)

海峡两岸医药卫生交流协会烧创伤暨组织修复专委会

通信作者:夏照帆,海军军医大学第一附属医院烧伤科,全军烧伤研究所,上海

200433, Email: xiazaofan@163.com

【摘要】 糖尿病足具有较高的致残率和致死率,负压伤口疗法(NPWT)是治疗糖尿病足创面的有效技术之一,但不规范的应用往往导致感染、出血、坏死等并发症,严重影响治疗结局。中国海峡两岸医药卫生交流协会烧创伤暨组织修复专委会组织烧伤科、骨科、血管外科、内分泌科、创面修复科等从事糖尿病足治疗的专家共同讨论和编写了《负压伤口疗法在糖尿病足创面治疗中的应用全国专家共识(2021 版)》。本共识以循证医学证据为基础,结合最新的临床研究进展,旨在形成 NPWT 治疗糖尿病足创面的规范化方案,供临床医师参考,以促进糖尿病足临床诊疗水平的提高。

【关键词】 负压伤口疗法; 糖尿病足; 溃疡

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National expert consensus on the application of negative pressure wound therapy in the treatment of diabetic foot wounds (2021 version)

Tissue Repair of Burns and Trauma Committee, Cross-Straits Medicine Exchange Association of China

Corresponding author: Xia Zhaofan, Burn Institute of PLA, Department of Burn Surgery, the First Affiliated Hospital of Naval Medical University, Shanghai 200433, China, Email: xiazaofan@163.com

【Abstract】 Diabetic foot has a high rate of disability and mortality. Negative pressure wound therapy (NPWT) is one of the effective techniques in treating diabetic foot wounds, but

the non-standard use of it often leads to infections, bleeding, necrosis and other complications, seriously affecting the outcome. Tissue Repair of Burns and Trauma Committee and Cross-Straits Medicine Exchange Association organized experts of multiple disciplinary specialties including burns, orthopedics, vascular surgery, endocrinology, wound repair, who are engaged in the treatment of diabetic foot to discuss and write the "National expert consensus on the application of negative pressure wound therapy in the treatment of diabetic foot wounds (2021 version)". This consensus is based on evidence-based medicine and combined with the latest clinical research progress, aiming to form a standardized plan for the treatment of diabetic foot wounds with NPWT. It can be used as a reference for clinicians, so as to promote the improvement of clinical diagnosis and treatment of diabetic foot.

【Key words】 Negative-pressure wound therapy; Diabetic foot; Ulcer

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1 背景

糖尿病足是糖尿病中晚期的一种严重并发症,是指因下肢远端神经异常、血管病变导致的足部感染、溃疡或深层组织破坏。据国际糖尿病足组织报道:在全球,每年因糖尿病足导致的截肢人数超过 100 万,每 20 秒就有 1 人因糖尿病足而截肢^[1]。据统计,2017 年全球糖尿病患者为 4.25 亿,预计到 2045 年将增长至 6.29 亿。《新英格兰医学杂志》发表专家述评指出:19%~34% 的糖尿病患者会发展为糖尿病足溃疡,糖尿病足患者截肢后 5 年病死率超过 70%,合并肾脏透析的糖尿病足患者截肢后的 2 年病死率高达 74%^[2]。糖尿病足患者的死亡风险甚至远超许多恶性肿瘤,其较高的致残率和致死率已经成为威胁人们健康的主要杀手,因此,如何预防和

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治疗糖尿病足成为临床亟须解决的问题。

糖尿病足治疗涉及多个学科,需要系统地综合治疗,包括血糖控制、外科清创、血管再通、减压治疗、支持治疗等,其中控制创面感染、促进组织修复是预防截肢或降低截肢平面的关键^[3-4]。自从 1993 年德国 Wim Fleischmann 首创负压伤口疗法(NPWT)概念并将其用于临床后,NPWT 就被公认为具有改善创面引流、增加血流灌注、促进肉芽组织生长等作用。目前,NPWT 被广泛用于各种急、慢性创面的治疗,包括糖尿病足溃疡。2016 年美国创面愈合协会在糖尿病足溃疡治疗指南中将 NPWT 作为 I 类证据等级推荐,指出 NPWT 可通过减少水肿,去除细菌产物、促进肉芽组织生长等途径改善创面愈合,并推荐在其他治疗无效时应考虑使用^[5]。2017 年欧洲创面管理协会在报告文件中指出,NPWT 可促进肉芽组织增殖、加速创面愈合^[6]。国际糖尿病足工作组在 2019 年糖尿病足防治国际指南中推荐使用负压治疗以促进溃疡的愈合^[1]。

NPWT 作为糖尿病足创面治疗的重要辅助治疗技术,其在创面的应用需要规范化的管理,包括在糖尿病足创面的应用条件、参数调整及效果评估等。2004 年图森专家共识会议(Tucson expert consensus conference)首次制订了 NPWT 在糖尿病足溃疡方面的应用指南^[7]。Andros 等^[8]在 2006 年进行更新修订,对 NPWT 在糖尿病足创面的临床应用提出了指导性的建议。近年来,NPWT 发展迅速,在基础研究和临床应用方面均取得了许多进展,特别是在临床实践方面取得了较多新的研究证据,使得我们对 NPWT 的认识也不断提高。基于上述原因,以循证医学证据为基础,结合最新的临床研究进展,中国海峡两岸医药卫生交流协会烧创伤暨组织修复专委会组织烧伤科、骨科、血管外科、内分泌科、创面修复科等从事糖尿病足治疗的专家共同讨论和编写了《负压伤口疗法在糖尿病足创面治疗中的应用全国专家共识(2021 版)》,针对 NPWT 在糖尿病足治疗中的应用管理及预后评估等提出最佳的临床实践治疗方案,旨在形成规范化的治疗方案,供临床医师应用参考,促进糖尿病足临床诊疗水平的提高。

2 方法

2.1 数据检索

查找 NPWT 在糖尿病足创面治疗中应用的高质

量文献,检索关键词: vacuum sealing drainage(VSD)、vacuum assisted closure(VAC)、vacuum-assisted therapy、negative pressure wound therapy (NPWT)、topical negative pressure (TNP) therapy、suction wound closure therapy (SWCT)、diabetic foot、diabetic ulcer、diabetic wound; 数据库:《PubMed》《Embase》《Cochrane Library databases》;检索时间为从建库开始至 2020 年 7 月 1 日;相关引用文献辅助手工检索,搜索限定为人类疾病相关;文献类型为荟萃分析(meta-analyses)、系统评价(systematic reviews)、随机对照试验(RCT)、回顾性系统研究(retrospective series reviews)、临床病例系统研究(clinical case series reviews)、专家意见(expert panel recommendations)。

2.2 证据分级标准和推荐强度

参考 2001 年牛津证据分级与推荐意见强度,本共识证据分级与推荐强度见表 1。根据德尔菲调查研究方法,每条证据均需专家组成员独立评估,最终经多次反复评估获得一致的推荐意见。

表 1 证据分级标准及其对应推荐强度分类

项目	内容
证据分级	
强	基于设计良好的随机对照试验、荟萃分析或系统评价
中	基于设计良好的队列研究或病例对照研究
弱	基于设计良好的病例系统研究及专家意见
推荐强度	
强	治疗明确有效或专家高度一致认可
中	治疗可能产生的风险与效果不是非常明确
弱	现阶段倾向性选择、现阶段证据不足的专家意见

注:此表参考 2001 年牛津证据分级与推荐意见强度^[9]并在其基础上进行汇总修改

3 推荐

3.1 NPWT 在糖尿病足创面治疗中的管理应用

3.1.1 NPWT 在糖尿病足创面治疗中的应用概述

糖尿病足创面的治疗需要多个学科的协同参与^[10-11],其治疗目标不是单一地避免溃疡感染扩散或者降低截肢平面,而是综合性的,包括预防全身动脉粥样硬化性疾病的发生,延缓糖尿病相关并发症进展,预防心、脑血管事件的发生及降低糖尿病足患者病死率等^[12]。目前,NPWT 已成为糖尿病足创面治疗中的一项重要辅助治疗技术^[13-25]。多个临床随机对照研究证实,与传统糖尿病足创面治疗方式相比较,NPWT 可明显提高创面愈合率、缩短创面愈合时间、降低截肢率^[26-38],已被美国创面愈合协

会和欧洲创面管理协会推荐应用^[39-41]。

专家推荐意见(推荐强度为强,证据等级为强):NPWT在增加创面局部血流灌注、促进肉芽组织增生、加速创面愈合等方面具有良好作用,推荐在糖尿病足创面治疗中应用。

3.1.2 NPWT在糖尿病足创面治疗中的应用条件 NPWT主要作用机制来自其形成的“封闭”环境和“负压引流”作用,基于NPWT使用的适应证和禁忌证,结合糖尿病足的发生、发展机制,NPWT在糖尿病足创面的应用需要具备一定的条件。

专家推荐意见(推荐强度为中,证据等级为中):NPWT的应用条件为(1)创面坏死组织清除、创面感染得到控制,即糖尿病足创面经过清创术后,坏死组织基本清除、创面感染基本控制,特别是筋膜间隔、组织间隙等隐蔽感染已得到控制^[42-49];(2)创面出血风险得到控制,即清创术后彻底止血,创面无活动性出血、无暴露的血管损伤^[7,50-51],同时无严重的凝血功能障碍或其他潜在出血风险,国际标准化比值 >2.0 且 <3.0 ;(3)创面缺血风险得到控制,即肢体远端血流灌注良好或经球囊扩张/血管成形术后,肢体远端血流有效改善、创面血流灌注良好,经皮氧分压 >40 mmHg(1 mmHg=0.133 kPa)或踝肱指数 >0.9 且 <1.3 或趾肱指数 ≥ 0.6 ^[52-58]。

3.1.3 NPWT系统参数设定 NPWT的模式可分为持续、间歇和可变负压3种。持续负压模式是负压维持在一个稳定水平,是目前临床最常用的模式。间歇和可变负压模式是近年来使用的新模式,负压在所设定的时间间隔内循环启停,在部分可移动式负压机器中可实现。近年来,许多研究表明间歇负压和可变负压模式较持续负压模式更有利于促进局部血液循环及肉芽组织生长。间歇负压模式一般设定为维持负压5 min、暂停2 min,如此循环,但其启停时易引起组织变形导致创面疼痛。可变负压模式是在设定的压力范围内产生规律性的循环波动负压,其最小负压值不会降到0,而仍有一定程度的负压(如-10 mmHg),一定程度上降低了组织变形引起的创面疼痛,更容易被患者接受。

专家推荐意见(推荐强度为中,证据等级为中):单纯神经病变性溃疡,无明显血管病变时,负压参数设定可参考其他常见创面,压力设定推荐介于-125~-80 mmHg之间^[59-60]。血管病变性溃疡或者神经、血管混合病变性溃疡,考虑其血管狭窄或闭塞,负压系统压力设定推荐介于-80~-60 mmHg^[61]。

关于负压模式,本共识建议在术后48 h内选择持续负压模式,随后使用间歇负压模式(负压吸引5 min,暂停2 min)或可变负压模式(压力介于-80~-10 mmHg)。

注意负压值应根据患者个体情况和创面大小进行调节^[62-65]:(1)当创面较大或复杂难以严密封闭时,可适当增加负压值;(2)行皮肤移植或真皮支架移植术后,选择持续负压模式吸引5~7 d;(3)对凝血功能障碍或长期使用抗凝药存在潜在出血风险的患者应适当调低负压值;(4)采用间歇负压模式可能会引起创面疼痛,可根据患者的耐受程度选择可变负压或持续负压模式。

3.1.4 NPWT治疗糖尿病足创面的效果评估和处理 糖尿病足创面的外科清创通常采用有限、分次清创的蚕食清创原则。足部软组织丰富、筋膜间隔较多,经多次清创手术后创面依然可能残留坏死组织,尤其是隐蔽感染灶无法彻底清除,存在感染发生或扩散的风险^[66]。此外,缺血性创面虽经血管再通、血运重建,但依然有短时间内血管再闭、创面缺血的风险。同时,对于部分需长期服用抗凝药物的患者,负压装置可能会加重创面出血的风险^[67]。

专家推荐意见(推荐强度为中,证据等级为中):在应用NPWT装置时,推荐每天进行仔细评估,包括观察创面红肿、疼痛情况,创周皮肤颜色、皮温改变情况,以及创面引流液的性状、颜色、气味和引流量等,并结合血液检验、影像学检查及全身情况等指标,评估创面的感染、缺血、出血情况^[68-71]。如创面感染没有得到控制,或组织缺血坏死进一步加重,或创面出现活动性出血时,需及时去除负压材料,并重新评估创面情况,待创面感染得到控制、组织缺血改善、出血风险消除后方可继续应用负压装置^[72];如创面疼痛加重或水肿加重,在排除创面感染、组织缺血及全身情况所致后,可降低或暂停负压,或更换负压治疗模式并密切观察,必要时可拆除负压装置^[73]。

负压装置应用1次或2次后,需要对其应用效果进行全面评估,其效果评价和推荐处理措施如下^[74-77]。(1)显效:创面新生肉芽组织生长或创面缩小、创周出现上皮化,推荐继续应用;(2)有效:创面感染或组织缺血得到改善,创面红润、血流灌注良好,推荐可继续应用1次或2次,并进一步评估其效果;(3)无效:创面感染或组织缺血未得到改善,出现感染加重或组织坏死,建议停用,待血管再通、创面感染控制后进行重新评估。

3.1.5 NPWT 泡沫材料更换时间 目前常用的负压泡沫材料可分为 2 类:聚乙烯醇材料和聚氨酯材料,前者亲水性较好,结构较致密、孔径较小(100~300 μm),在创面渗出液体较少时,容易变硬堵管,甚至卡压创面、引起组织缺血,因此要随时观察、及时更换;后者呈疏水性、孔径较大(500~650 μm),不易变硬,但肉芽组织易于长入,应用时间亦不宜过长,否则肉芽组织会长入泡沫多孔状结构中,去除材料时将创面产生损伤并造成不必要的失血^[78]。

专家推荐意见(推荐强度为弱,证据等级为弱):糖尿病足清创术后 NPWT 泡沫材料更换时间需根据评估情况来确定^[79-82]。如无感染、活动性出血或组织缺血,推荐 3~5 d 进行更换,最长不宜超过 7 d;糖尿病足创面植皮术后, NPWT 材料更换时间可适当延长,推荐为 5~7 d。

3.1.6 NPWT 在糖尿病足创面治疗中的应用的常见并发症与处理 NPWT 在糖尿病足创面应用前需要充分掌握其应用条件,在应用过程中需要持续进行评估,根据创面情况及时停止使用负压装置或及时更换负压泡沫材料^[83-85]。相比于传统的治疗技术, NPWT 并没有明显增加并发症,对可能出现的并发症及其推荐处理措施如下。

专家推荐意见(推荐强度为中,证据等级为弱):(1)出现创面出血或感染加重时,需立即停用 NPWT、拆除负压装置,经彻底止血或清创换药控制感染后进行重新评估^[86];(2)出现组织缺血加重或坏死时,需立即停用 NPWT、拆除负压装置,待组织缺血、血流灌注改善后进行重新评估^[87];(3)创周出现皮肤湿疹或正常皮肤贴膜处出现张力性水泡等最常见的并发症时,可通过贴膜保护创面周围皮肤、降低负压值,贴膜时尽可能减少皮肤牵拉等以预防并发症^[88];(4)如有肉芽组织长入泡沫材料,则负压装置留置时间不应过长,需定期进行更换。在拆除负压材料时,尽可能彻底去除泡沫材料,以避免其成为异物引起继发感染^[89];(5)创面疼痛加重或水肿加重时,排除创面感染、组织缺血及全身情况等影响后,可暂停负压或更换负压治疗模式进行观察,必要时拆除负压装置^[90]。

3.1.7 NPWT 的经济学评价 许多研究对 NPWT 的经济效益进行了评价。多数研究结果显示,相对于常规治疗,采用 NPWT 减少了换药次数、降低了医疗物资及人力资源的消耗,治疗费用和医

疗成本耗费更低,综合效价比更高^[91-105]。

专家推荐意见(推荐强度为中,证据等级为中):鉴于将 NPWT 用于治疗糖尿病足创面可以减少医疗物资及人力资源消耗,具有较好的经济效益,推荐在糖尿病足创面使用 NPWT。

3.1.8 改良 NPWT 在糖尿病足创面治疗中的应用 近年来,许多改良 NPWT 被用于糖尿病足创面的治疗,包括灌注-冲洗负压^[64,106-114]、局部给氧负压^[115]等,初步研究表明其在预防和控制创面感染、促进创面清创等方面较传统 NPWT 具有一定优势^[107,116-118],但目前高质量的研究证据不多,尚需进行大规模的多中心临床验证。

专家推荐意见(推荐强度为弱,证据等级为弱):灌注-冲洗负压、局部给氧负压等改良新型负压装置在糖尿病足创面治疗中的应用尚缺乏足够的证据支持,不推荐常规用于治疗糖尿病足创面。

3.2 NPWT 在糖尿病足创面治疗中的具体应用

3.2.1 合并软组织感染创面 糖尿病足创面常常伴发感染,严重者会发展为广泛的蜂窝织炎、骨髓炎,甚至坏死性筋膜炎,从而威胁生命,对严重感染者需要综合评估患者整体情况,必要时行截肢手术^[119-121]。对保肢患者,创面需要进行多次清创手术,待坏死组织基本清除、感染基本控制后,再进一步行血管再通等治疗,改善远端组织缺血以确保创面血流灌注充足^[122-125],在此基础上可应用 NPWT。

专家推荐意见(推荐强度为中,证据等级为弱):对于合并软组织感染创面,在创面感染得到控制前,不建议常规应用 NPWT,在坏死组织基本清除、创面感染得到控制后,可应用 NPWT,在治疗过程中需要持续进行评估,根据临床实际情况停止负压治疗或定期更换负压泡沫材料继续负压治疗^[126-128]。

3.2.2 合并骨质、肌腱外露创面 对于合并骨质、肌腱外露的糖尿病足创面,优先推荐采用皮瓣移植修复,如机体条件不足或皮瓣移植手术存在较大风险、患者要求保守换药或植皮手术治疗时,可采用 NPWT 进行辅助治疗,以改善创基条件或培育肉芽组织,为皮瓣转移或植皮创造条件。

专家推荐意见(推荐强度为弱,证据等级为弱):对合并骨质、肌腱外露创面,下列 3 种情况可采用 NPWT 治疗:(1)创基条件不良,尚需继续清创、换药处理以改善创基条件^[129-131];(2)血管狭窄、血运不良或皮瓣移植存在较大风险^[132];(3)小面积骨质、肌

腱外露^[196,133]。

3.2.3 合并骨髓炎创面 糖尿病足创面感染如未得到及时合理处置,常常会侵袭骨质发展为骨髓炎,不仅增加感染控制的难度,也增加截肢/趾的风险,因此针对存在深部软组织感染、骨突出部位溃疡或创面反复破溃不愈时,应考虑骨髓炎可能。如明确诊断或高度怀疑为骨髓炎,则需慎用 NPWT。

专家推荐意见(推荐强度为中,证据等级为弱):对合并骨髓炎的创面,需彻底清创、清除死骨,并辅以 2~4 周系统性抗生素治疗,待感染有效控制后方可应用 NPWT^[134-136],应用过程中需持续进行评估,密切观察创面局部感染情况,根据评估情况及时停用 NPWT 或更换负压泡沫材料^[137-139];对无法有效控制的骨髓炎感染,慎用 NPWT^[140-141]。

3.2.4 皮肤移植或皮瓣转移术后 研究表明,无论是网状皮片移植还是自体邮票状小皮片移植,使用恒定的负压进行持续吸引,可有效提高皮片的成活率、缩短创面愈合时间^[142-145]。

专家推荐意见(推荐强度为中,证据等级为弱):皮肤行移植术后,推荐采用持续负压吸引模式,压力设置介于-100~-80 mmHg,根据创面渗出情况,推荐使用时间为 5~7 d^[146-148];皮瓣转移术后,不推荐常规应用 NPWT,部分皮瓣转移手术如交腿皮瓣、腹部包埋皮瓣等延迟皮瓣需要较长时间断蒂时,可考虑行 NPWT 保护创面、引流渗液,但需注意应用时避免压迫皮瓣蒂部,可选择持续吸引 48 h,随后改为间歇负压吸引模式^[149-150]:5 min 负压吸引,2 min 暂停,压力设置介于-80~-60 mmHg,或可变负压模式:压力设置介于-80~-10 mmHg。根据创面渗出情况,推荐使用时间为 3~5 d。

3.2.5 真皮替代物移植创面 研究证实 NPWT 可以有效促进真皮替代物的血管化,同时由于其引流效果良好,避免了真皮替代物下积液,加之其降低了换药频率,减少了创面外露感染的可能,可提高真皮替代物的移植成功率,为后期皮肤移植提供良好的受皮条件^[151-154]。

专家推荐意见(推荐强度为中,证据等级为弱):推荐真皮替代物移植术后应用负压装置,采用持续负压吸引模式,压力设置介于-100~-80 mmHg^[155-156],根据创面渗出情况,推荐应用时间为 5~7 d。

3.2.6 截肢/趾术后伤口

3.2.6.1 截肢/趾术后 I 期缝合伤口 负压装置可通过其良好的引流作用减少残端内渗液积聚,同

时负压装置的固定作用有助于截肢/趾残端组织的稳定,促进组织重塑、伤口闭合。

专家推荐意见(推荐强度为中,证据等级为弱):针对截肢/趾术后 I 期缝合伤口,推荐应用负压装置^[157-159]。建议选择持续负压吸引模式,压力设置介于-80~-60 mmHg,根据创面渗出情况,推荐应用时间为 5~7 d。

3.2.6.2 截肢/趾术后残端创面 部分截肢/趾术后因为创面条件不足不能进行 I 期缝合,或部分截肢/趾术后虽进行 I 期缝合,但因为残端缺血或感染等原因出现伤口不愈,针对上述情况,可根据临床实际情况应用 NPWT 进行辅助治疗。

专家推荐意见(推荐强度为强,证据等级为强):对于截肢术后残端创面,在缺血、出血风险控制 and 坏死组织基本清除干净、感染控制后,推荐应用负压装置,可促进创面肉芽组织增生、组织修复^[160-161]。建议选择间歇负压吸引模式:负压吸引 5 min,暂停 2 min,压力设置介于-80~-60 mmHg,或可变负压模式,压力设置介于-80~-10 mmHg。根据创面渗出情况,推荐应用时间为 3~5 d。

4 结语

糖尿病足的创面治疗需要多学科合作、综合治疗。NPWT 是糖尿病足创面治疗的重要辅助技术,规范的管理应用可以达到改善创面引流、增强血流灌注、促进创面愈合的目的。鉴于其应用后潜在的风险,我们通过文献系统评价的方式拟定本共识建议,旨在为 NPWT 在糖尿病足创面治疗中的应用形成规范化的治疗方案。但需要指出,本共识部分证据等级不高,尚需更多的高质量临床随机对照研究进一步明确 NPWT 在糖尿病足创面治疗中的应用方式和效果。

《负压伤口疗法在糖尿病足创面治疗中的应用全国专家共识(2021 版)》

编写组

组长:夏照帆(海军军医大学第一附属医院)

专家组成员(单位名称以拼音排序、姓名以姓氏笔画排序):北京大学第一医院温冰,北京大学人民医院徐海林,北京世纪坛医院王江宁,北京中医药大学东直门医院鞠上,东部战区空军医院王爱萍,福建医科大学附属协和医院陈昭宏,广州市正骨医院洪劲松,哈尔滨市第五医院李宗瑜,海军军医大学叶小飞,海军军医大学第一附属医院王光毅、包俊敏、肖仕初、袁良喜、徐茂锦,江南大学附属医院(无锡市第三人民医院)吕国忠,江苏南通大学附属医院张逸,解放军战略支援部队特色医学中心姜玉峰,解放军总医院第四医学中心郝岱峰,空军军医大学第一附属医院胡大海,陆军军医大学(第三军医大学)第一附属医院罗高兴,宁波市第六医院王欣,上海交通大学医学院

附属瑞金医院刘琰,上海市第六人民医院施忠民,深圳大学第一附属医院吴军,四川大学华西医院冉兴无,浙江大学医学院附属第二医院韩春茂,浙江大学医学院附属邵逸夫医院李宏焯,《中华烧伤杂志》梁光萍,中南大学湘雅医院唐举玉

执笔:纪世召、刘晓彬、肖仕初、黄洁(海军军医大学第一附属医院)

利益冲突 所有编写组成员均声明不存在利益冲突

参考文献

- [1] Schaper NC, van Netten JJ, Apelqvist J, et al. Practical Guidelines on the prevention and management of diabetic foot disease (IWGDF 2019 update) [J]. *Diabetes Metab Res Rev*, 2020, 36 Suppl 1:e3266. DOI:10.1002/dmrr.3266.
- [2] Armstrong DG, Attinger CE, Boulton AJ, et al. Guidelines regarding negative wound therapy (NPWT) in the diabetic foot[J]. *Ostomy Wound Manage*, 2004, 50(4B Suppl):S3-27.
- [3] Everett E, Mathioudakis N. Update on management of diabetic foot ulcers[J]. *Ann N Y Acad Sci*, 2018, 1411(1): 153-165. DOI: 10.1111/nyas.13569.
- [4] Bakker K, Apelqvist J, Lipsky BA, et al. The 2015 IWGDF guidance documents on prevention and management of foot problems in diabetes: development of an evidence-based global consensus[J]. *Diabetes Metab Res Rev*, 2016, 32 Suppl 1: S2-6. DOI:10.1002/dmrr.2694.
- [5] Lavery LA, Davis KE, Berriman SJ, et al. WHS guidelines update: diabetic foot ulcer treatment guidelines[J]. *Wound Repair Regen*, 2016, 24(1):112-126. DOI:10.1111/wrr.12391.
- [6] Apelqvist J, Willy C, Fagerdahl AM, et al. EWMA document: negative pressure wound therapy[J]. *J Wound Care*, 2017, 26(Suppl 3):S1-154. DOI:10.12968/jowc.2017.26.Sup3.S1.
- [7] Armstrong DG, Boulton AJM, Bus SA. Diabetic foot ulcers and their recurrence[J]. *N Engl J Med*, 2017, 376(24):2367-2375. DOI: 10.1056/NEJMra1615439.
- [8] Andros G, Armstrong DG, Attinger CE, et al. Consensus statement on negative pressure wound therapy (V. A. C. Therapy) for the management of diabetic foot wounds[J]. *Ostomy Wound Manage*, 2006, Suppl:S1-32.
- [9] Phillips B, Ball C, Sackett D, et al. Evidence-based Medicine Levels of Evidence[EB/OL]. (2001-05-06) [2021-06-08]. http://www.cebm.net/levels_of_evidence.asp.
- [10] Rys P, Borys S, Hohendorff J, et al. NPWT in diabetic foot wounds—a systematic review and meta-analysis of observational studies[J]. *Endocrine*, 2020, 68(1):44-55. DOI:10.1007/s12020-019-02164-9.
- [11] Mohseni S, Aalaa M, Atlasi R, et al. The effectiveness of negative pressure wound therapy as a novel management of diabetic foot ulcers: an overview of systematic reviews[J]. *J Diabetes Metab Disord*, 2019, 18(2):625-641. DOI:10.1007/s40200-019-00447-6.
- [12] Braun LR, Fisk WA, Lev-Tov H, et al. Diabetic foot ulcer: an evidence-based treatment update[J]. *Am J Clin Dermatol*, 2014, 15(3):267-281. DOI:10.1007/s40257-014-0081-9.
- [13] Zhang D, Li Z, Wang Z, et al. MicroRNA-126: a promising biomarker for angiogenesis of diabetic wounds treated with negative pressure wound therapy[J]. *Diabetes Metab Syndr Obes*, 2019, 12:1685-1696. DOI:10.2147/DMSO.S199705.
- [14] Mu S, Hua Q, Jia Y, et al. Effect of negative-pressure wound therapy on the circulating number of peripheral endothelial progenitor cells in diabetic patients with mild to moderate degrees of ischaemic foot ulcer[J]. *Vascular*, 2019, 27(4):381-389. DOI:10.1177/1708538119836360.
- [15] Almeida JE, Suárez R, Gibson E. A histological analysis of chronic wounds treated with negative pressure wound therapy to aid healing: a case series[J]. *J Wound Care*, 2018, 27(Suppl 2):S28-34. DOI:10.12968/jowc.2018.27.Sup2.S28.
- [16] Ma Z, Li Z, Shou K, et al. Negative pressure wound therapy: regulating blood flow perfusion and microvessel maturation through microvascular pericytes[J]. *Int J Mol Med*, 2017, 40(5): 1415-1425. DOI:10.3892/ijmm.2017.3131.
- [17] Izzo V, Meloni M, Giurato L, et al. The effectiveness of negative pressure therapy in diabetic foot ulcers with elevated protease activity: a case series[J]. *Adv Wound Care (New Rochelle)*, 2017, 6(1):38-42. DOI:10.1089/wound.2016.0700.
- [18] Wang T, He R, Zhao J, et al. Negative pressure wound therapy inhibits inflammation and upregulates activating transcription factor-3 and downregulates nuclear factor- κ B in diabetic patients with foot ulcerations[J/OL]. *Diabetes Metab Res Rev*, 2017, 34(4) [2020-06-08]. <https://pubmed.ncbi.nlm.nih.gov/27883358/>. DOI: 10.1002/dmrr.2871. [Published online ahead of print Feb 20, 2017].
- [19] Yang SL, Han R, Liu Y, et al. Negative pressure wound therapy is associated with up-regulation of bFGF and ERK1/2 in human diabetic foot wounds[J]. *Wound Repair Regen*, 2014, 22(4): 548-554. DOI:10.1111/wrr.12195.
- [20] Guffanti A. Negative pressure wound therapy in the treatment of diabetic foot ulcers: a systematic review of the literature[J]. *J Wound Ostomy Continence Nurs*, 2014, 41(3): 233-237. DOI: 10.1097/WON.0000000000000021.
- [21] Lone AM, Zaroo MI, Laway BA, et al. Vacuum-assisted closure versus conventional dressings in the management of diabetic foot ulcers: a prospective case-control study[J]. *Diabet Foot Ankle*, 2014, 5. DOI:10.3402/dfa.v5.23345.
- [22] Seo SG, Yeo JH, Kim JH, et al. Negative-pressure wound therapy induces endothelial progenitor cell mobilization in diabetic patients with foot infection or skin defects[J]. *Exp Mol Med*, 2013, 45(11):e62. DOI:10.1038/emm.2013.129.
- [23] Nain PS, Uppal SK, Garg R, et al. Role of negative pressure wound therapy in healing of diabetic foot ulcers[J]. *J Surg Tech Case Rep*, 2011, 3(1):17-22. DOI:10.4103/2006-8808.78466.
- [24] Khamaisi M, Balanson S. Dysregulation of wound healing mechanisms in diabetes and the importance of negative pressure wound therapy (NPWT) [J/OL]. *Diabetes Metab Res Rev*, 2017, 33(7) [2020-06-08]. <https://pubmed.ncbi.nlm.nih.gov/28817237/>. DOI:10.1002/dmrr2929. [Published online ahead of print Sep 11, 2017].
- [25] Jung JA, Yoo KH, Han SK, et al. Influence of negative-pressure wound therapy on tissue oxygenation in diabetic feet[J]. *Adv Skin Wound Care*, 2016, 29(8):364-370. DOI:10.1097/01.ASW.0000483038.18331.a4.
- [26] James S, Sureshkumar S, Elamurugan TP, et al. Comparison of vacuum-assisted closure therapy and conventional dressing on wound healing in patients with diabetic foot ulcer: a randomized controlled trial[J]. *Niger J Surg*, 2019, 25(1):14-20. DOI:10.4103/njs.NJS_14_18.
- [27] Liu Z, Dumville JC, Hinchliffe RJ, et al. Negative pressure wound therapy for treating foot wounds in people with diabetes mellitus [J]. *Cochrane Database Syst Rev*, 2018, 10(10): CD010318. DOI: 10.1002/14651858.CD010318.pub3.
- [28] Yang SL, Zhu LY, Han R, et al. Effect of negative pressure wound therapy on cellular fibronectin and transforming growth factor- β 1 expression in diabetic foot wounds[J]. *Foot Ankle Int*, 2017, 38(8):893-900. DOI:10.1177/1071100717704940.
- [29] Wang R, Feng Y, Di B. Comparisons of negative pressure wound

- therapy and ultrasonic debridement for diabetic foot ulcers: a network meta-analysis[J]. *Int J Clin Exp Med*, 2015, 8(8): 12548-12556.
- [30] Zhang J, Hu ZC, Chen D, et al. Effectiveness and safety of negative-pressure wound therapy for diabetic foot ulcers: a meta-analysis[J]. *Plast Reconstr Surg*, 2014, 134(1): 141-151. DOI: 10.1097/PRS.0000000000000275.
- [31] Yarwood-Ross L, Dignon AM. NPWT and moist wound dressings in the treatment of the diabetic foot[J]. *Br J Nurs*, 2012, 21(15): S26, S28, S30-32. DOI:10.12968/bjon.2012.21.Sup20.S26.
- [32] Game FL, Hinchliffe RJ, Apelqvist J, et al. A systematic review of interventions to enhance the healing of chronic ulcers of the foot in diabetes[J]. *Diabetes Metab Res Rev*, 2012, 28 Suppl 1: S119-141. DOI:10.1002/dmrr.2246.
- [33] Karatepe O, Eken I, Acet E, et al. Vacuum assisted closure improves the quality of life in patients with diabetic foot[J]. *Acta Chir Belg*, 2011, 111(5):298-302.
- [34] Blume PA, Walters J, Payne W, et al. Comparison of negative pressure wound therapy using vacuum-assisted closure with advanced moist wound therapy in the treatment of diabetic foot ulcers: a multicenter randomized controlled trial[J]. *Diabetes Care*, 2008, 31(4):631-636. DOI:10.2337/dc07-2196.
- [35] Akbari A, Moodi H, Ghiasi F, et al. Effects of vacuum-compression therapy on healing of diabetic foot ulcers: randomized controlled trial[J]. *J Rehabil Res Dev*, 2007, 44(5): 631-636. DOI: 10.1682/jrrd.2007.01.0002.
- [36] Lavery LA, Barnes SA, Keith MS, et al. Prediction of healing for postoperative diabetic foot wounds based on early wound area progression[J]. *Diabetes Care*, 2008, 31(1): 26-29. DOI: 10.2337/dc07-1300.
- [37] Eginton MT, Brown KR, Seabrook GR, et al. A prospective randomized evaluation of negative-pressure wound dressings for diabetic foot wounds[J]. *Ann Vasc Surg*, 2003, 17(6):645-649. DOI: 10.1007/s10016-003-0065-3.
- [38] Chiang N, Rodda OA, Sleight J, et al. Effects of topical negative pressure therapy on tissue oxygenation and wound healing in vascular foot wounds[J]. *J Vasc Surg*, 2017, 66(2): 564-571. DOI: 10.1016/j.jvs.2017.02.050.
- [39] Lipsky BA, Berendt AR, Cornia PB, et al. 2012 Infectious Diseases Society of America clinical practice guideline for the diagnosis and treatment of diabetic foot infections[J]. *Clin Infect Dis*, 2012, 54(12):e132-173. DOI:10.1093/cid/cis346.
- [40] Kunze KN, Hamid KS, Lee S, et al. Negative-pressure wound therapy in foot and ankle surgery[J]. *Foot Ankle Int*, 2020, 41(3): 364-372. DOI:10.1177/1071100719892962.
- [41] Isaac AL, Armstrong DG. Negative pressure wound therapy and other new therapies for diabetic foot ulceration: the current state of play[J]. *Med Clin North Am*, 2013, 97(5):899-909. DOI:10.1016/j.mena.2013.03.015.
- [42] Lima R, Coltro PS, Júnior FJA. Negative pressure therapy for the treatment of complex wounds[J]. *Rev Col Bras Cir*, 2017, 44(1): 81-93. DOI:10.1590/0100-69912017001001.
- [43] Deng W, Boey J, Chen B, et al. Platelet-rich plasma, bilayered acellular matrix grafting and negative pressure wound therapy in diabetic foot infection[J]. *J Wound Care*, 2016, 25(7):393-397. DOI: 10.12968/jowc.2016.25.7.393.
- [44] Hasan MY, Teo R, Nather A. Negative-pressure wound therapy for management of diabetic foot wounds: a review of the mechanism of action, clinical applications, and recent developments[J]. *Diabet Foot Ankle*, 2015, 6:27618. DOI:10.3402/dfa.v6.27618.
- [45] Tansarli GS, Vardakas KZ, Stratoulas C, et al. Vacuum-assisted closure versus closure without vacuum assistance for preventing surgical site infections and infections of chronic wounds: a meta-analysis of randomized controlled trials[J]. *Surg Infect (Larchmt)*, 2014, 15(4):363-367. DOI:10.1089/sur.2013.028.
- [46] Vig S, Dowsett C, Berg L, et al. Evidence-based recommendations for the use of negative pressure wound therapy in chronic wounds: steps towards an international consensus[J]. *J Tissue Viability*, 2011, 20 Suppl 1:S1-18. DOI:10.1016/j.jtv.2011.07.002.
- [47] Vikatmaa P, Juutilainen V, Kuukasjärvi P, et al. Negative pressure wound therapy: a systematic review on effectiveness and safety[J]. *Eur J Vasc Endovasc Surg*, 2008, 36(4):438-448. DOI: 10.1016/j.ejvs.2008.06.010.
- [48] Suess JJ, Kim PJ, Steinberg JS. Negative pressure wound therapy: evidence-based treatment for complex diabetic foot wounds[J]. *Curr Diab Rep*, 2006, 6(6): 446-450. DOI: 10.1007/s11892-006-0077-9.
- [49] Medical Advisory Secretariat. Negative pressure wound therapy: an evidence-based analysis[J]. *Ont Health Technol Assess Ser*, 2006, 6(14):1-38.
- [50] Capobianco CM, Zgonis T. An overview of negative pressure wound therapy for the lower extremity[J]. *Clin Podiatr Med Surg*, 2009, 26(4):619-631. DOI:10.1016/j.cpm.2009.08.002.
- [51] Clare MP, Fitzgibbons TC, McMullen ST, et al. Experience with the vacuum assisted closure negative pressure technique in the treatment of non-healing diabetic and dysvascular wounds[J]. *Foot Ankle Int*, 2002, 23(10):896-901. DOI:10.1177/107110070202301002.
- [52] Meloni M, Izzo V, Vainieri E, et al. Management of negative pressure wound therapy in the treatment of diabetic foot ulcers [J]. *World J Orthop*, 2015, 6(4):387-393. DOI: 10.5312/wjo.v6.i4.387.
- [53] Miller JD, Carter E, Hatch DC, et al. Use of collagenase ointment in conjunction with negative pressure wound therapy in the care of diabetic wounds: a case series of six patients[J]. *Diabet Foot Ankle*, 2015, 6:24999. DOI:10.3402/dfa.v6.24999.
- [54] A N, Khan WS, J P. The evidence-based principles of negative pressure wound therapy in trauma & orthopedics[J]. *Open Orthop J*, 2014, 8:168-177. DOI:10.2174/1874325001408010168.
- [55] Schintler MV. Negative pressure therapy: theory and practice[J]. *Diabetes Metab Res Rev*, 2012, 28 Suppl 1:S72-77. DOI:10.1002/dmrr.2243.
- [56] Nather A, Chionh SB, Han AY, et al. Effectiveness of vacuum-assisted closure (VAC) therapy in the healing of chronic diabetic foot ulcers[J]. *Ann Acad Med Singap*, 2010, 39(5): 353-358.
- [57] Armstrong DG, Lavery LA, Boulton AJ. Negative pressure wound therapy via vacuum-assisted closure following partial foot amputation: what is the role of wound chronicity?[J]. *Int Wound J*, 2007, 4(1):79-86. DOI:10.1111/j.1742-481X.2006.00270.x.
- [58] Mendonca DA, Cosker T, Makwana NK. Vacuum-assisted closure to aid wound healing in foot and ankle surgery[J]. *Foot Ankle Int*, 2005, 26(9):761-766. DOI:10.1177/107110070502600915.
- [59] Lee KN, Ben-Nakhi M, Park EJ, et al. Cyclic negative pressure wound therapy: an alternative mode to intermittent system[J]. *Int Wound J*, 2015, 12(6):686-692. DOI:10.1111/iwj.12201.
- [60] Borys S, Hohendorf J, Koblik T, et al. Negative-pressure wound therapy for management of chronic neuropathic noninfected diabetic foot ulcerations-short-term efficacy and long-term outcomes[J]. *Endocrine*, 2018, 62(3): 611-616. DOI: 10.1007/s12020-018-1707-0.
- [61] Lavery LA, Murdoch DP, Kim PJ, et al. Negative pressure wound

- therapy with low pressure and gauze dressings to treat diabetic foot wounds[J]. *J Diabetes Sci Technol*, 2014, 8(2): 346-349. DOI: 10.1177/1932296813519012.
- [62] Lavery LA, La Fontaine J, Thakral G, et al. Randomized clinical trial to compare negative-pressure wound therapy approaches with low and high pressure, silicone-coated dressing, and polyurethane foam dressing[J]. *Plast Reconstr Surg*, 2014, 133(3): 722-726. DOI:10.1097/01.prs.0000438046.83515.6a.
- [63] Venturi ML, Attinger CE, Mesbahi AN, et al. Mechanisms and clinical applications of the vacuum-assisted closure (VAC) device: a review[J]. *Am J Clin Dermatol*, 2005, 6(3): 185-194. DOI: 10.2165/00128071-200506030-00005.
- [64] Hall KD, Patterson JS. Three cases describing outcomes of negative-pressure wound therapy with instillation for complex wound healing[J]. *J Wound Ostomy Continence Nurs*, 2019, 46(3): 251-255. DOI:10.1097/WON.0000000000000516.
- [65] Borys S, Hohendorff J, Frankfurter C, et al. Negative pressure wound therapy use in diabetic foot syndrome-from mechanisms of action to clinical practice[J]. *Eur J Clin Invest*, 2019, 49(4): e13067. DOI:10.1111/eci.13067.
- [66] Kimura T, Watanabe Y, Tokuoka S, et al. Utility of skin perfusion pressure values with the Society for Vascular Surgery Wound, Ischemia, and foot infection classification system[J]. *J Vasc Surg*, 2019, 70(4): 1308-1317. DOI:10.1016/j.jvs.2019.01.045.
- [67] Sajid MT, Qu M, Shaheen N, et al. Comparison of negative pressure wound therapy using vacuum-assisted closure with advanced moist wound therapy in the treatment of diabetic foot ulcers[J]. *J Coll Physicians Surg Pak*, 2015, 25(11): 789-793.
- [68] Salvo P, Calisi N, Melai B, et al. Temperature- and pH-sensitive wearable materials for monitoring foot ulcers[J]. *Int J Nanomedicine*, 2017, 12: 949-954. DOI:10.2147/IJN.S121726.
- [69] Yazdanpanah L, Nasiri M, Adarvishi S. Literature review on the management of diabetic foot ulcer[J]. *World J Diabetes*, 2015, 6(1): 37-53. DOI:10.4239/wjdv6.i1.37.
- [70] Zheng Y, Wang X, Zhang L, et al. Successful treatment of a patient with complicated diabetic foot wound: a case report[J]. *Int J Low Extrem Wounds*, 2014, 13(2): 140-146. DOI:10.1177/1534734614529650.
- [71] Kim YH, Hwang KT, Kim JT, et al. What is the ideal interval between dressing changes during negative pressure wound therapy for open traumatic fractures? [J]. *J Wound Care*, 2015, 24(11): 536, 538-540, 542. DOI: 10.12968/jowc.2015.24.11.536.
- [72] Abbas M, Uçkay I, Lipsky BA. In diabetic foot infections antibiotics are to treat infection, not to heal wounds[J]. *Expert Opin Pharmacother*, 2015, 16(6): 821-832. DOI: 10.1517/14656566.2015.1021780.
- [73] Schwartz JA, Goss SG, Facchin F, et al. Single-use negative pressure wound therapy for the treatment of chronic lower leg wounds[J]. *J Wound Care*, 2015, 24 Suppl 2: S4-9. DOI: 10.12968/jowc.2015.24.Sup2.S4.
- [74] Li X, Liu J, Liu Y, et al. Negative pressure wound therapy accelerates rats diabetic wound by promoting agenesi s[J]. *Int J Clin Exp Med*, 2015, 8(3): 3506-3513.
- [75] Cigna E, Fino P, Onesti MG, et al. Diabetic foot infection treatment and care[J]. *Int Wound J*, 2016, 13(2): 238-242. DOI: 10.1111/iwj.12277.
- [76] Georgakarakos E, Charalampidis D, Kakagia D, et al. Current achievements with topical negative pressure to improve wound healing in dehiscent ischemic stumps of diabetic patients: a case series[J]. *Int J Low Extrem Wounds*, 2013, 12(2): 138-145. DOI: 10.1177/1534734613483769.
- [77] Goudie EB, Gendies C, Lantis JC. Multimodal therapy as an algorithm to limb salvage in diabetic patients with large heel ulcers[J]. *Int Wound J*, 2012, 9(2): 132-138. DOI: 10.1111/j.1742-481X.2011.00869.x.
- [78] McElroy EF. Use of negative pressure wound therapy with instillation and a reticulated open cell foam dressing with through holes in the acute care setting[J]. *Int Wound J*, 2019, 16(3): 781-787. DOI:10.1111/iwj.13097.
- [79] Hafeez K, Haroon-Ur-Rashid, Kaim Khani GM, et al. Vacuum Assisted Closure- utilization as home based therapy in the management of complex diabetic extremity wounds[J]. *Pak J Med Sci*, 2015, 31(1): 95-99. DOI:10.12669/pjms.311.6093.
- [80] Yao M, Fabbri M, Hayashi H, et al. A retrospective cohort study evaluating efficacy in high-risk patients with chronic lower extremity ulcers treated with negative pressure wound therapy[J]. *Int Wound J*, 2014, 11(5): 483-488. DOI:10.1111/j.1742-481X.2012.01113.x.
- [81] Dzieciuchowicz Ł, Kruszyna Ł, Krasieński Z, et al. Monitoring of systemic inflammatory response in diabetic patients with deep foot infection treated with negative pressure wound therapy[J]. *Foot Ankle Int*, 2012, 33(10): 832-837. DOI: 10.3113/FAI.2012.0832.
- [82] McCallon SK, Knight CA, Valiulus JP, et al. Vacuum-assisted closure versus saline-moistened gauze in the healing of postoperative diabetic foot wounds[J]. *Ostomy Wound Manage*, 2000, 46(8): 28-32, 34.
- [83] Schwartz JA, Fuller A, Avdagic E, et al. Use of NPWT with and without Soft Port technology in infected foot wounds undergoing partial diabetic foot amputation[J]. *J Wound Care*, 2015, 24 Suppl 9: S4-12. DOI:10.12968/jowc.2015.24.Sup9.S4.
- [84] Günel Ö, Tuncel U, Turan A, et al. The use of vacuum-assisted closure and GranuFoam Silver® dressing in the management of diabetic foot ulcer[J]. *Surg Infect (Larchmt)*, 2015, 16(5): 558-565. DOI:10.1089/sur.2014.093.
- [85] Armstrong DG, Andros G. Use of negative pressure wound therapy to help facilitate limb preservation[J]. *Int Wound J*, 2012, 9 Suppl 1: S1-7. DOI:10.1111/j.1742-481X.2012.01015.x.
- [86] Desai KK, Hahn E, Pulikkottil B, et al. Negative pressure wound therapy: an algorithm[J]. *Clin Plast Surg*, 2012, 39(3): 311-324. DOI:10.1016/j.cps.2012.05.002.
- [87] Fife CE, Walker D, Thomson B, et al. The safety of negative pressure wound therapy using vacuum-assisted closure in diabetic foot ulcers treated in the outpatient setting[J]. *Int Wound J*, 2008, 5 Suppl 2: S17-22. DOI:10.1111/j.1742-481X.2008.00467.x.
- [88] Nather A, Hong NY, Lin WK, et al. Effectiveness of bridge V.A.C. dressings in the treatment of diabetic foot ulcers[J]. *Diabet Foot Ankle*, 2011, 2[2020-06-08]. <https://pubmed.ncbi.nlm.nih.gov/22396825/>. DOI: 10.3402/dfa.v2i0.5893. [Published online ahead of print Mar 4, 2011].
- [89] Bondokji S, Rangaswamy M, Reuter C, et al. Clinical efficacy of a new variant of a foam-based NWPT system[J]. *J Wound Care*, 2011, 20(2): 62, 64-67. DOI:10.12968/jowc.2011.20.2.72.
- [90] Armstrong DG, Lavery LA, Abu-Rumman P, et al. Outcomes of subatmospheric pressure dressing therapy on wounds of the diabetic foot[J]. *Ostomy Wound Manage*, 2002, 48(4): 64-68.
- [91] Delhougne G, Hogan C, Tarka K, et al. A retrospective, cost-minimization analysis of disposable and traditional negative pressure wound therapy medicare paid claims[J]. *Ostomy Wound Manage*, 2018, 64(1): 26-33.
- [92] Liu S, He CZ, Cai YT, et al. Evaluation of negative-pressure wound therapy for patients with diabetic foot ulcers: systematic review

- and meta-analysis[J]. *Ther Clin Risk Manag*, 2017, 13: 533-544. DOI:10.2147/TCRM.S131193.
- [93] Driver VR, Blume PA. Evaluation of wound care and health-care use costs in patients with diabetic foot ulcers treated with negative pressure wound therapy versus advanced moist wound therapy[J]. *J Am Podiatr Med Assoc*, 2014, 104(2): 147-153. DOI: 10.7547/0003-0538-104.2.147.
- [94] Whitehead SJ, Forest-Bendien VL, Richard JL, et al. Economic evaluation of Vacuum Assisted Closure® therapy for the treatment of diabetic foot ulcers in France[J]. *Int Wound J*, 2011, 8(1):22-32. DOI:10.1111/j.1742-481X.2010.00739.x.
- [95] White R, McIntosh C. A review of the literature on topical therapies for diabetic foot ulcers. Part 2: Advanced treatments[J]. *J Wound Care*, 2009, 18(8): 335-341. DOI: 10.12968/jowc.2009.18.8.43633.
- [96] Wu SC, Armstrong DG. Clinical outcome of diabetic foot ulcers treated with negative pressure wound therapy and the transition from acute care to home care[J]. *Int Wound J*, 2008, 5 Suppl 2: S10-16. DOI:10.1111/j.1742-481X.2008.00466.x.
- [97] Flack S, Apelqvist J, Keith M, et al. An economic evaluation of VAC therapy compared with wound dressings in the treatment of diabetic foot ulcers[J]. *J Wound Care*, 2008, 17(2): 71-78. DOI: 10.12968/jowc.2008.17.2.28181.
- [98] Apelqvist J, Armstrong DG, Lavery LA, Boulton AJ. Resource utilization and economic costs of care based on a randomized trial of vacuum-assisted closure therapy in the treatment of diabetic foot wounds[J]. *Am J Surg*, 2008, 195(6): 782 - 788. DOI: 10.1016/j.amjsurg.2007.06.023.
- [99] Frykberg RG, Williams DV. Negative-pressure wound therapy and diabetic foot amputations: a retrospective study of payer claims data[J]. *J Am Podiatr Med Assoc*, 2007, 97(5):351-359. DOI: 10.7547/0970351.
- [100] Lavery LA, Boulton AJ, Niezgoda JA, et al. A comparison of diabetic foot ulcer outcomes using negative pressure wound therapy versus historical standard of care[J]. *Int Wound J*, 2007, 4(2):103-113. DOI:10.1111/j.1742-481X.2007.00317.x.
- [101] Braakenburg A, Obdeijn MC, Feitz R, et al. The clinical efficacy and cost effectiveness of the vacuum-assisted closure technique in the management of acute and chronic wounds: a randomized controlled trial[J]. *Plast Reconstr Surg*, 2006, 118(2):390-397. DOI: 10.1097/01.prs.0000227675.63744.af.
- [102] 翁晓春, 李春, 周松兰, 等. 负压封闭引流治疗糖尿病足溃疡疗效的 Meta 分析[J]. *昆明医科大学学报*, 2017, 38(4):80-83.
- [103] 关小宏, 李宝军, 高歌, 等. 持续负压封闭引流技术在高龄糖尿病足患者治疗中的应用研究[J/CD]. *中华损伤与修复杂志: 电子版*, 2015, 10(6):45-46. DOI:10.3877/cma.j.issn.1673-9450.2015.06.012.
- [104] 肖黎, 李立柱, 吴石白, 等. 负压封闭引流技术与传统换药方法在糖尿病足治疗中的疗效对比及卫生经济学评价[J/CD]. *中华损伤与修复杂志: 电子版*, 2016, 11(5):330-333. DOI:10.3877/cma.j.issn.1673-9450.2016.05.003.
- [105] Nord D. Cost-effectiveness in wound care[J]. *Zentralbl Chir*, 2006, 131 Suppl 1:S185-188. DOI:10.1055/s-2006-921433.
- [106] Duarte B, Cabete J, Formiga A, et al. Dakin's solution: is there a place for it in the 21st century? [J]. *Int Wound J*, 2017, 14(6): 918-920. DOI:10.1111/iwj.12728.
- [107] Driver RK. Utilizing the VeraFlo™ instillation negative pressure wound therapy system with advanced care for a case study[J]. *Cureus*, 2016, 8(11):e903. DOI:10.7759/cureus.903.
- [108] Felte R, Gallagher KE, Tinkoff GH, et al. A case review series of christiania care health system's experience with negative pressure wound therapy instillation[J]. *Cureus*, 2016, 8(11): e865. DOI:10.7759/cureus.865.
- [109] Neas ED, Dunn JA, Silva ED, et al. Peroxy pyruvic acid-containing topical anti-infective: a potential candidate for a wound instillation solution[J]. *Adv Wound Care (New Rochelle)*, 2016, 5(10):432-443. DOI:10.1089/wound.2015.0682.
- [110] Kim PJ, Attinger CE, Steinberg JS, et al. Negative pressure wound therapy with instillation: past, present, and future[J]. *Surg Technol Int*, 2015, 26:51-56.
- [111] Dalla Paola L. Diabetic foot wounds: the value of negative pressure wound therapy with instillation[J]. *Int Wound J*, 2013, 10 Suppl 1:S25-31. DOI:10.1111/iwj.12174.
- [112] Armstrong DG, Marston WA, Reyzelman AM, et al. Comparative effectiveness of mechanically and electrically powered negative pressure wound therapy devices: a multicenter randomized controlled trial[J]. *Wound Repair Regen*, 2012, 20(3): 332-341. DOI:10.1111/j.1524-475X.2012.00780.x.
- [113] Zelen CM, Stover B, Nielson D, et al. A prospective study of negative pressure wound therapy with integrated irrigation for the treatment of diabetic foot ulcers[J]. *Eplasty*, 2011, 11:e5.
- [114] Scimeca CL, Bharara M, Fisher TK, et al. Novel use of insulin in continuous-instillation negative pressure wound therapy as "wound chemotherapy"[J]. *J Diabetes Sci Technol*, 2010, 4(4): 820-824. DOI:10.1177/193229681000400408.
- [115] 张美光, 李志清, 王甲汉, 等. 负压封闭引流联合含氧液冲洗修复糖尿病患者慢性创面的效果观察[J]. *中华烧伤杂志*, 2014, 30(2):116-123. DOI:10.3760/cma.j.issn.1009-2587.2014.02.005.
- [116] Kim PJ, Attinger CE, Crist BD, et al. Negative pressure wound therapy with instillation: review of evidence and recommendations[J]. *Wounds*, 2015, 27(12):S2-S19.
- [117] Dale AP, Saeed K. Novel negative pressure wound therapy with instillation and the management of diabetic foot infections[J]. *Curr Opin Infect Dis*, 2015, 28(2): 151-157. DOI: 10.1097/QCO.0000000000000146.
- [118] Brinkert D, Ali M, Naud M, et al. Negative pressure wound therapy with saline instillation: 131 patient case series[J]. *Int Wound J*, 2013, 10 Suppl 1:S56-60. DOI:10.1111/iwj.12176.
- [119] Iacopi E, Coppelli A, Goretti C, et al. Necrotizing fasciitis and the diabetic foot[J]. *Int J Low Extrem Wounds*, 2015, 14(4): 316-327. DOI:10.1177/1534734615606534.
- [120] Sun S, Wang C, Chen D, et al. Combating superbug without antibiotic on a postamputation wound in a patient with diabetic foot[J]. *Int J Low Extrem Wounds*, 2016, 15(1):74-77. DOI:10.1177/1534734615595736.
- [121] Kim BS, Choi WJ, Baek MK, et al. Limb salvage in severe diabetic foot infection[J]. *Foot Ankle Int*, 2011, 32(1):31-37. DOI:10.3113/FAI.2011.0031.
- [122] Yan Y, Li W, Song Y, et al. Semiclosure wound therapy plus negative pressure wound therapy for an older patient with grade 4 diabetic foot with concomitant vascular occlusion: a case report [J]. *Medicine (Baltimore)*, 2019, 98(44): e17786. DOI: 10.1097/MD.00000000000017786.
- [123] Hajimohammadi K, Makhdooni K, Zabihi RE, et al. NPWT: a gate of hope for patients with diabetic foot ulcers[J]. *Br J Nurs*, 2019, 28(12):S6-9. DOI:10.12968/bjon.2019.28.12.S6.
- [124] Shahi N, Bradley S, Vowden K, et al. Diabetic bullae: a case series and a new model of surgical management[J]. *J Wound Care*, 2014, 23(6):326, 328-330. DOI:10.12968/jowc.2014.23.6.326.
- [125] Tian M, Jiang YZ, Niu YW, et al. A severely infected diabetic foot treated successfully without using systemic antibiotics[J]. *Int J Low Extrem Wounds*, 2012, 11(4): 296-298. DOI: 10.1177/

- 1534734612458286.
- [126] Tricco AC, Antony J, Vafaei A, et al. Seeking effective interventions to treat complex wounds: an overview of systematic reviews [J]. *BMC Med*, 2015, 13:89. DOI:10.1186/s12916-015-0288-5.
- [127] Kennedy A, Van Zant RS. Diverse applications of negative pressure wound therapy: a multiple case report [J]. *Physiother Theory Pract*, 2006, 22(2):83-90. DOI:10.1080/09593980600588781.
- [128] Gesslein M, Horch RE. Interdisciplinary management of complex chronic ulcers using vacuum assisted closure therapy and "buried chip skin grafts" [J]. *Zentralbl Chir*, 2006, 131 Suppl 1: S170-173. DOI:10.1055/s-2006-921460.
- [129] Abe Y, Hashimoto I, Ishida S, et al. The perifascial areolar tissue and negative pressure wound therapy for one-stage skin grafting on exposed bone and tendon [J]. *J Med Invest*, 2018, 65(1/2): 96-102. DOI:10.2152/jmi.65.96.
- [130] Hiermer R, Degreef H, Vranckx JJ, et al. Skin grafting and wound healing-the "dermato-plastic team approach" [J]. *Clin Dermatol*, 2005, 23(4):343-352. DOI:10.1016/j.clindermatol.2004.07.028.
- [131] Smud -Orehovec S, Mance M, Halužan D, et al. Defect reconstruction of an infected diabetic foot using split- and full-thickness skin grafts with adjuvant negative pressure wound therapy: a case report and review of the literature [J]. *Wounds*, 2018, 30(11):E108-E115.
- [132] Ramanujam CL, Zgonis T. Surgical soft tissue closure of severe diabetic foot infections: a combination of biologics, negative pressure wound therapy, and skin grafting [J]. *Clin Podiatr Med Surg*, 2012, 29(1):143-146. DOI:10.1016/j.cpm.2011.10.004.
- [133] Eneroth M, van Houtum WH. The value of debridement and Vacuum-Assisted Closure (V. A. C.) Therapy in diabetic foot ulcers [J]. *Diabetes Metab Res Rev*, 2008, 24 Suppl 1:S76-80. DOI: 10.1002/dmrr.852.
- [134] Godoy-Santos AL, Rosemberg LA, de Cesar-Netto C, et al. The use of bioactive glass S53P4 in the treatment of an infected Charcot foot: a case report [J]. *J Wound Care*, 2019, 28(Suppl 1):S14-17. DOI:10.12968/jowc.2019.28.Sup1.S14.
- [135] Mikami T, Kaida E, Yabuki Y, et al. Negative pressure wound therapy followed by basic fibroblast growth factor spray as a recovery technique in partial necrosis of distally based sural flap for calcaneal osteomyelitis: a case report [J]. *J Foot Ankle Surg*, 2018, 57(4):816-820. DOI:10.1053/j.jfas.2017.11.011.
- [136] Drampalos E, Mohammad HR, Kosmidis C, et al. Single stage treatment of diabetic calcaneal osteomyelitis with an absorbable gentamicin-loaded calcium sulphate/hydroxyapatite biocomposite: The Silo technique [J]. *Foot (Edinb)*, 2018, 34:40-44. DOI:10.1016/j.foot.2017.11.011.
- [137] Raphael A, Gonzales J. Use of cryopreserved umbilical cord with negative pressure wound therapy for complex diabetic ulcers with osteomyelitis [J]. *J Wound Care*, 2017, 26(Suppl 10):S38-44. DOI:10.12968/jowc.2017.26.Sup10.S38.
- [138] Dalla Paola L, Carone A, Boscarino G, et al. Combination of open subtotal calcanectomy and stabilization with external fixation as limb salvage procedure in hindfoot-infected diabetic foot ulcers [J]. *Int J Low Extrem Wounds*, 2016, 15(4):332-337. DOI:10.1177/1534734616667865.
- [139] Ramanujam CL, Stapleton JJ, Zgonis T. Negative-pressure wound therapy in the management of diabetic Charcot foot and ankle wounds [J]. *Diabet Foot Ankle*, 2013, 4. DOI: 10.3402/dfa.v4i0.20878.
- [140] Lipsky BA, Berendt AR, Deery HG, et al. Diagnosis and treatment of diabetic foot infections [J]. *Plast Reconstr Surg*, 2006, 117(7 Suppl):S212-238. DOI:10.1097/01.prs.0000222737.09322.77.
- [141] Namgoong S, Jung SY, Han SK, et al. Clinical experience with surgical debridement and simultaneous meshed skin grafts in treating biofilm-associated infection: an exploratory retrospective pilot study [J]. *J Plast Surg Hand Surg*, 2020, 54(1): 47-54. DOI: 10.1080/2000656X.2019.1673170.
- [142] Gkotsoulas E. Split thickness skin graft of the foot and ankle bolstered with negative pressure wound therapy in a diabetic population: the results of a retrospective review and review of the literature [J]. *Foot Ankle Spec*, 2020, 13(5):383-391. DOI:10.1177/1938640019863267.
- [143] Wu CC, Chew KY, Chen CC, et al. Antimicrobial-impregnated dressing combined with negative-pressure wound therapy increases split-thickness skin graft engraftment: a simple effective technique [J]. *Adv Skin Wound Care*, 2015, 28(1):21-27. DOI:10.1097/01.ASW.0000459038.81701.fb.
- [144] Kisch T, Liodaki ME, Mauss KL, et al. Reduced amputation rate by circular TNP application on split-skin grafts after deep dermal foot scalds in insulin-dependent diabetic patients [J]. *J Burn Care Res*, 2015, 36(5): e253-258. DOI: 10.1097/BCR. 0000000000000184.
- [145] Chan SY, Wong KL, Lim JX, et al. The role of Renasys-GO™ in the treatment of diabetic lower limb ulcers: a case series [J]. *Diabet Foot Ankle*, 2014, 5:24718. DOI:10.3402/dfa.v5.24718.
- [146] Chiummariello S, Del Torto G, Iera M, et al. Negative pressure dressing in split-thickness skin grafts: experience with an alternative method [J]. *Wounds*, 2013, 25(11):324-327.
- [147] Ross RE, Aflaki P, Gendics C, et al. Complex lower extremity wounds treated with skin grafts and NPWT: a retrospective review [J]. *J Wound Care*, 2011, 20(10): 490, 492-495. DOI: 10.12968/jowc.2011.20.10.490.
- [148] Randall KL, Booth BA, Miller AJ, et al. Use of an acellular regenerative tissue matrix in combination with vacuum-assisted closure therapy for treatment of a diabetic foot wound [J]. *J Foot Ankle Surg*, 2008, 47(5):430-433. DOI:10.1053/j.jfas.2008.04.012.
- [149] Wada A, Ferreira MC, Tuma Júnior P, et al. Experience with local negative pressure (vacuum method) in the treatment of complex wounds [J]. *Sao Paulo Med J*, 2006, 124(3):150-153. DOI:10.1590/s1516-31802006000300008.
- [150] 胡恺轩, 章宏伟, 周芳, 等. 负压技术治疗复杂性和难愈性创面疗效观察 [J]. *中华烧伤杂志*, 2009, 25(4):249-252. DOI:10.3760/cma.j.issn.1009-2587.2009.04.004.
- [151] Cazzell S, Vayser D, Pham H, et al. A randomized clinical trial of a human acellular dermal matrix demonstrated superior healing rates for chronic diabetic foot ulcers over conventional care and an active acellular dermal matrix comparator [J]. *Wound Repair Regen*, 2017, 25(3):483-497. DOI:10.1111/wrr.12551.
- [152] Guo X, Mu D, Gao F. Efficacy and safety of acellular dermal matrix in diabetic foot ulcer treatment: a systematic review and meta-analysis [J]. *Int J Surg*, 2017, 40: 1-7. DOI: 10.1016/j.ijsu.2017.02.008.
- [153] Rupert P. Human acellular dermal wound matrix for complex diabetic wounds [J]. *J Wound Care*, 2016, 25(4):S17-18, S20-21. DOI:10.12968/jowc.2016.25.Sup4.S17.
- [154] Cole WE. DermACELL: human acellular dermal matrix allograft a case report [J]. *J Am Podiatr Med Assoc*, 2016, 106(2):133-137. DOI:10.7547/14-091.
- [155] Protzman NM, Brigido SA. Recent advances in acellular regenerative tissue scaffolds [J]. *Clin Podiatr Med Surg*, 2015, 32(1): 147-159. DOI:10.1016/j.cpm.2014.09.008.
- [156] Espensen EH, Nixon BP, Lavery LA, et al. Use of subatmospheric (VAC) therapy to improve bioengineered tissue grafting in

diabetic foot wounds[J]. J Am Podiatr Med Assoc, 2002, 92(7): 395-397. DOI:10.7547/87507315-92-7-395.

[157] Ahmed ME, Mohammed MS, Mahadi SI. Primary wound closure of diabetic foot ulcers by debridement and stitching[J]. J Wound Care. 2016, 25(11):650-654. DOI:10.12968/jowc.2016.25.11.650.

[158] Richter K, Knudson B. Vacuum-assisted closure therapy for a complicated, open, above-the-knee amputation wound[J]. J Am Osteopath Assoc, 2013, 113(2):174-176.

[159] Stansby G, Wealleans V, Wilson L, et al. Clinical experience of a new NPWT system in diabetic foot ulcers and post-amputation wounds[J]. J Wound Care, 2010, 19(11): 496, 498-502. DOI: 10.12968/jowc.2010.19.11.79706.

[160] Armstrong DG, Lavery LA, Diabetic Foot Study Consortium. Negative pressure wound therapy after partial diabetic foot amputation: a multicentre, randomised controlled trial[J]. Lancet, 2005, 366(9498): 1704-1710. DOI: 10.1016/S0140-6736(05)67695-7.

[161] Ulusal AE, Sahin MS, Ulusal B, et al. Negative pressure wound therapy in patients with diabetic foot[J]. Acta Orthop Traumatol Turc, 2011, 45(4):254-260. DOI:10.3944/AOTT.2011.2283.

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