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# 神经血管蒂皮瓣联合抗生素硫酸钙治疗踝周感染创面<sup>△</sup>

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**摘要:** [目的] 介绍神经血管蒂皮瓣联合抗生素硫酸钙治疗踝周感染创面的手术技术和初步临床结果。[方法] 2016年4月—2022年6月对21例踝周感染创面采用神经血管蒂皮瓣联合抗生素硫酸钙治疗。术前高频彩色超声标记创面周围隐神经及胫后动脉穿支。清创后切开皮瓣一侧皮缘, 在轴线及旋转点附近找到隐神经及胫后动脉穿支, 保留轴线两侧1.5~2.0 cm宽筋膜组织。将皮瓣通过开放隧道转位覆盖创面。将制备好的抗生素硫酸钙颗粒填塞于皮瓣深层空腔内。在显微镜下将皮瓣携带的隐神经与供区可吻合皮神经行端-端吻合。供瓣区创面直接闭合或取大腿中厚皮片植皮修复。[结果] 21块皮瓣及供瓣区植皮全部成活, 供瓣区切口均一期愈合。随访时间(15.2±4.9)个月。皮瓣外形良好, 耐磨、质地柔软。所有患者均无感染复发并恢复正常生活。末次随访足踝关节功能评定: 优10例, 良10例, 可1例, 优良率95.2%。[结论] 神经血管蒂皮瓣联合抗生素硫酸钙治疗踝周感染创面, 操作简单, 效果良好。

**关键词:** 隐神经营养血管皮瓣, 穿支皮瓣, 硫酸钙, 感染, 创面修复

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**Neurovascular pedicle flap combined with antibiotic calcium sulfate in treatment of infectious wounds around the ankle //** WANG Hui<sup>a</sup>, DAI Jiang-ping<sup>a</sup>, ZHOU Tong<sup>a</sup>, LIU Yu-jie<sup>a</sup>, MA Tie-peng<sup>a</sup>, LIU Ying<sup>b</sup>, ZHANG Yi-han<sup>a</sup>. a. Department of Hand Surgery, b. Department of Functional Examination, The Second Hospital of Tangshan City, Tangshan, Hebei 063000, China

**Abstract:** [Objective] To introduce the surgical technique and preliminary clinical results of neurovascular pedicle flap combined with antibiotic calcium sulfate in treatment of infectious wounds around the ankle. [Methods] From April 2016 to June 2022, a total of 21 patients with infectious wounds around the ankle were treated by neurovascular pedicle flap combined with antibiotic calcium sulfate. The saphenous nerve and posterior tibial artery perforators around the wound was marked by high-frequency color doppler ultrasound preoperatively. After debridement, the skin margin on one side of the flap was firstly cut to expose the saphenous nerve and posterior tibial artery perforators near the flap axis and rotation point. After that, the flap was freed with subcutaneous fascia tissue about 1.5~2.0 cm in wide on both sides of the flap axis retained. The flap was transferred to cover the wound by an open tunnel. The prepared antibiotic calcium sulfate particles were filled into the cavity below the flap. Subsequently, the saphenous nerve was anastomosed end-to-end with the nerve stumps at donor site under microscope. The flap donor site was sutured directly or repaired by intermediate split thickness skin graft harvested from the thigh. [Results] All 21 patients had flaps and skin grafts at donor site survived uneventfully with the incisions at the donor site healed in excellent grade, and were followed up for (15.2±4.9) months in a mean. All patients returned to normal life without infection recurrence, had appearance of the flaps looked good with a wear-resistant and soft texture. At the latest follow-up, the function of the affected ankle and foot was marked as excellent in 10, good in 10, and fair in 1, with excellent and good rate of 95.2%. [Conclusion] This neurovascular pedicle flap combined with antibiotic calcium sulfate is a good option for treating infectious wounds at the distal leg and the ankle and foot with advantages of simple procedure and good outcome.

**Key words:** saphenous neurovascular flaps, perforator flap, calcium sulfate, infection, wound repair

随着工农业机械化不断普及、交通运输业蓬勃发展, 各种外伤导致的踝周感染性创面病例日益增多<sup>[1, 2]</sup>。由于这些部位皮下组织较薄, 深层骨质、肌

腱容易外露, 创面较难愈合, 如处理不及时常导致急、慢性骨髓炎<sup>[3, 4]</sup>。因此, 如何快速、有效治疗此类伤病, 一直是骨科研究热点。2016年4月—2022

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年6月,作者采用隐神经营养血管穿支带蒂皮瓣联合载抗生素硫酸钙治疗踝周感染性创面21例,获得良好临床疗效,现报道如下。

## 1 手术技术

### 1.1 术前准备

入院后常规血常规、血糖、C-反应蛋白(C-reactive protein, CRP)、红细胞沉降率(erythrocyte sedimentation rate, ESR)、降钙素原(procalcitonin, PCT)、肝肾功、凝血功能及X线片检查。根据细菌培养药敏试验结果,应用敏感抗生素。采用高频彩色多普勒超声诊断仪(频率7.5~20 MHz)对创面周围隐神经及胫后动脉穿支血管走行进行定位并体表标记,测量隐神经与各穿支血管间距离。选择较粗大(穿出深筋膜后口径 $\geq 0.5$  mm)并且距离隐神经较近的胫后动脉穿支作为皮瓣旋转点(图1a),以隐神经走行为轴线预构皮瓣切取范围。

### 1.2 麻醉与体位

根据创面的部位,患者采用平卧位或侧卧位。手术均在腰麻下进行,患侧大腿根部上气囊止血带止血。

### 1.3 手术操作

彻底清除创面内感染生物膜、炎性肉芽组织及外露坏死、感染的骨组织及肌腱,切除创缘直至 $>5$  mm的正常骨组织及 $>2$  mm正常的皮肤软组织(图1b)。创面、腔内组织多点取材,进行组织细菌培养和药敏试验<sup>[5]</sup>。取材位点包括感染生物膜、炎性肉芽组织、局部皮质骨、松质骨及内固定物周围等。碘伏溶液浸泡创面10 min,双氧水、生理盐水反复冲洗。按照术前皮瓣设计线切开一侧皮肤及深筋膜。首先在轴线附近找到隐神经,注意避免损伤周围伴行营养血管,确定将其包含在皮瓣内并在其深层切取皮瓣。在设计皮瓣旋转点附近解剖胫后动脉穿支(图1c),注意保护周围伴行静脉。确定穿支位置后,如创面较大或旋转点距离创面较远,建议选择带蒂岛状皮瓣修复创面,可根据穿支与隐神经的横向间距,确定皮瓣筋膜蒂宽度,一般保留轴线两侧1.5~2.0 cm宽筋膜组织;如创面较小或皮瓣旋转点距离创面较近,可选择“螺旋桨”方式切取皮瓣(图1d)。由近端向远端切取皮瓣直至旋转点。如“螺旋桨”式皮瓣旋转困难,可适当裸化胫后动脉穿支,注意避免损伤其伴行静脉。松止血带,观察皮瓣血运正常后,通过开放隧道将皮瓣旋转 $\leq 180^\circ$ 转位至创面。按照万古霉素0.5 g、

庆大霉素120 mg及硫酸钙粉末5 ml的比例均匀混合制成直径3 mm或4.8 mm大小固态颗粒(图1e),将制备好的载抗生素硫酸钙颗粒填塞于皮瓣深层空腔内。如创面周围有可吻合的皮神经断端,在显微镜下用10-0显微缝合线无张力将皮瓣携带的隐神经与供区皮神经行端-端吻合。缝合皮瓣及蒂部。供瓣区创面直接闭合或取大腿中厚游离皮片植皮修复(图1f)。皮瓣深层常规放置引流管。本组皮瓣面积为 $3.5\text{ cm}\times 2.5\text{ cm}\sim 18.0\text{ cm}\times 6.0\text{ cm}$ 。

### 1.4 术后处理

术后患肢抬高、烤灯保温、观察皮瓣血运变化,应用便携式多普勒诊断仪定期监测旋转点处胫后动脉穿支搏动。术后常规静脉滴注敏感抗生素10~14 d。定期复查血常规、CRP、ESR、PCT。保持引流管通畅,液体量 $\leq 10$  ml/24 h时,拔除引流管。术后2周拆除缝线,在康复师指导下逐渐进行患肢关节功能练习。末次随访,根据美国足踝外科协会(American Orthopaedic Foot and Ankle Society, AOFAS)后足功能评分对患肢足踝关节进行功能评定<sup>[6]</sup>。

## 2 临床资料

### 2.1 一般资料

本组共21例,男13例,女8例;年龄28~66岁,平均(46.9 $\pm$ 8.4)岁。均为外伤导致感染性创面并细菌培养结果阳性,其中铜绿假单胞菌8例,金黄色葡萄球菌5例,阴沟肠杆菌5例,鲍曼不动杆菌3例。创面部位:小腿下段12例,足踝部9例;骨外露6例,肌腱外露3例,骨与肌腱均外露12例。致伤原因:车祸伤12例,砸伤6例,绞伤3例。创面软组织缺损面积 $3.0\text{ cm}\times 1.5\text{ cm}\sim 13.0\text{ cm}\times 5.0\text{ cm}$ 。本研究获本院伦理委员会批准,所有患者均签署知情同意书。

### 2.2 初步结果

本组21块皮瓣全部成活,供瓣区移植皮片均成活,供瓣区切口均一期愈合。随访时间10~32个月,平均(15.2 $\pm$ 4.9)个月。皮瓣外形良好,耐磨、质地柔软。所有患者均无感染复发症状并恢复正常生活。末次随访,根据AOFAS评分对患肢足踝关节进行功能评定:优10例,良10例,可1例,优良率95.2%。

## 3 讨论

临床上外伤造成的踝周部感染性创面较为常见。治疗方案一般为根治性清创、填塞空腔、良好的创面覆盖，同时结合敏感抗生素治疗<sup>[7-11]</sup>。为保证彻底消灭创面内残留的生物膜及潜伏细菌，需要保证局部有较高的杀菌药物浓度，并且需要维持一定的时间<sup>[12, 13]</sup>。踝周感染性创面多有骨外露，周围皮肤软组织较薄、血供差，应用敏感抗生素输液治疗，创面局部很难达到所需的杀菌药物浓度，并且长时间静脉药物输液可导致多重耐药性及多器官功能损伤<sup>[14, 15]</sup>。因此，近年来局部采用抗生素载体治疗此

类疾病成为主流。既能保证抗生素局部持续达到较高杀菌浓度，又可降低全身血液药物浓度，从而大幅降低各种不良反应。其中载抗生素的骨水泥聚甲基丙烯酸甲酯临床最常使用，并取得很好的临床疗效，但聚甲基丙烯酸甲酯在体内不能自行降解、需要二次手术取出，固化过程中产生高温、降低抗生素活性是其主要缺点。硫酸钙作为新型可降解抗生素载体，生物相容性好、药物缓释时间长、释放率高、具有骨传导性，适合应用于局部感染性创面及骨髓炎的治疗<sup>[16, 17]</sup>。



图1. 患者女性，55岁。1a: 术前高频彩色多普勒超声探测胫后动脉穿支；1b: 术前创面外观及皮瓣设计；1c: 皮瓣切取，红色箭头所示为胫后动脉穿支；1d: 切取皮瓣呈现螺旋桨状；1e: 制备载抗生素硫酸钙颗粒；1f: 术后即刻皮瓣及供区外观；1g, 1h: 术后12个月随访，左踝关节背伸-跖屈活动良好，皮瓣外观良好。

Figure 1. A 55-years-old female. 1a: The posterior tibial artery perforators was probed by high-frequency color doppler ultrasound preoperatively; 1b: Preoperative wound appearance and flap design; 1c: Appearance of the flap cutting with the red arrow indicating the posterior tibial artery perforator; 1d: The flap was trimmed into a propeller-like shape; 1e: Preparation of antibiotic calcium sulfate particles; 1f: Appearance of the flap and donor site immediately postoperatively; 1g, 1h: Appearances 12 months postoperatively presented good flexion-extension range of motion.

本术式优点：(1) 皮瓣切取操作简便、供区副损伤小、无需精湛显微外科技术和复杂手术设备；(2) 皮瓣拥有隐神经营养血管和胫后动脉穿支两套供血系统，较传统穿支皮瓣或者皮神经营养血管皮瓣血供更充足，有助于机体防御能力、抗生素转运及骨组织愈合，而且可切取面积较大；(3) 不需要多次负压吸

引，一期彻底清创后立即行载抗生素硫酸钙填充、皮瓣覆盖，可减少手术次数及治疗时间、费用。据文献报道术后6周局部抗生素浓度依旧可以在最小抑菌浓度之上，大大降低感染的复发率<sup>[18]</sup>；(4) 术前应用高频彩色多普勒超声对创面周围隐神经及胫后动脉穿支血管走行进行测量并体表标记，选择最佳穿支血管

及旋转点,可缩窄皮瓣蒂部宽度、减少手术时间,做到精准化操作<sup>[19]</sup>;此外高频彩色多普勒超声可以真正探测出支配浅层皮肤血供的动脉穿支血管走行及位置,相比于手持便携式多普勒探测到有些穿支可能是动脉肌支而不是供养皮肤穿支,大大提高手术成功率;(5)皮瓣携带的皮神经与受区神经吻合,可重建皮瓣感觉;(6)硫酸钙固化过程中不产生热量,不会造成负载抗生素活性降低。缺点:(1)硫酸钙降解过程中释放出水分,术后伤口渗液较多,务必保证引流通畅;(2)相比骨水泥聚甲基丙烯酸甲酯,硫酸钙的价格较高,是其一大缺点。

本术式适应证:(1)各种原因导致的踝周感染性创面或急、慢性骨髓炎;(2)创面宽度 $\leq 1/2$ 肢体周径。禁忌证:(1)创面宽度 $> 1/2$ 肢体轴径者,建议选择游离皮瓣进行修复;(2)皮瓣供区皮肤软组织损伤或胫后动脉存在损伤或闭塞者。

操作注意事项:(1)术前高频彩色多普勒超声对创面周围胫后动脉穿支血管进行探测时,多标记一些动脉穿支点,术中尽量选择与隐神经靠近粗大的穿支血管作为皮瓣旋转点,这样可以缩窄皮瓣蒂部宽度,减小因缝合张力过大造成的蒂部受压、血管危象;(2)如皮瓣面积过大,为预防皮瓣血供不足,切取皮瓣时可携带深筋膜;(3)如创面较小或皮瓣旋转点距离创面较近,建议选择“螺旋桨”方式设计皮瓣,可减轻蒂部受压、直接闭合供瓣区创面,提高手术成功率并改善肢体外观;(4)因踝周皮肤较薄,感染性创面大多存在骨外露,容易造成骨坏死、骨感染,术中清创范围务必保证 $>5$  mm的正常骨组织及 $>2$  mm的正常皮肤软组织<sup>[20]</sup>;(5)术中取5个以上细菌培养标本进行组织细菌培养和药敏试验以提高致病菌准确率;(6)因硫酸钙降解过程中生成水分,术后1~2周内伤口渗液较多,皮瓣深层务必放置引流管并保证通畅,定期消毒,防止细菌随引流管进入伤口内部,待液体量 $\leq 10$  ml/24 h时拔除引流管。

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