

## NPWT联合灌洗系统治疗Wagner 3~5级糖尿病足合并感染的临床疗效对比分析\*

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**【摘要】** 目的 对比分析应用创面负压治疗(negative pressure wound therapy, NPWT)联合灌洗系统治疗Wagner 3~5级糖尿病足合并感染的临床效果。方法 回顾分析2016年1月-2020年1月,我科收治的100例Wagner分级为3~5级糖尿病足伴感染患者的临床资料,按照治疗方式分为联合治疗组(NPWT联合灌洗系统)和单一治疗组(仅使用NPWT)。观察患者创面感染细菌类型、创面细菌培养转阴的时间、血中炎症指标的情况(包括白细胞计数和C反应蛋白)。收集住院期间首次手术术前等待时间、住院期间手术次数、住院时间、NPWT使用时间、创面愈合时间,以及出院后患者在院外抗生素使用时间、最终创面愈合比率、创面最终愈合时间以及创面远期并发症(包括伤口裂开、新溃疡产生、感染复发、再入院、再手术,截肢)。结果 两组病例在年龄、性别、病程、损伤侧别、病损大小、合并疾病方面差异无统计学意义,同样在创面细菌种属及比率方面差异亦无统计学意义。但在创面细菌培养转阴时间方面,联合治疗组优于单一治疗组( $P<0.05$ )。在血中炎症指标中,除了联合组的C反应蛋白在术后一周时间点较单一组下降更明显外( $P<0.05$ ),余指标中两组无明显差异。尽管在住院期间手术次数、住院时间、NPWT使用时间、创面闭合时间方面,联合治疗组的指标均低于单一治疗组( $P<0.05$ ),但在远期创面并发症方面,两组患者差异无统计学意义。结论 采用NPWT联合灌洗系统治疗Wagner 3~5级糖尿病足合并感染,可以有效早期控制创面感染,减少创面细菌培养转阴的时间。同时刺激创面肉芽生长,早期有效覆盖创面。

**【关键词】** NPWT 灌洗系统 糖尿病足 感染 疗效

**Comparative Analysis of Clinical Efficacy of Negative Pressure Wound Therapy Plus Lavage System in the Treatment of Wagner Grade 3-5 Diabetic Foot Ulcers Combined with Infection** CHEN Yu<sup>1,2</sup>, LI Ya-xing<sup>1</sup>, LIU Xi<sup>1</sup>, YIN Shi-jiu<sup>1,2</sup>, OUYANG Xiang-yu<sup>3</sup>, ZHANG Hui<sup>1△</sup>. 1. Department of Osteology, West China Hospital, Sichuan University, Chengdu 610041, China; 2. West China Shangjin Hospital of Sichuan University/Chengdu Shangjin Nanfu Hospital, Chengdu 611730, China; 3. Hospital of Chengdu Office, People's Government of Tibet Autonomous Region, Chengdu 610041, China  
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**【Abstract】** **Objective** To compare and analyze the clinical efficacy of negative pressure wound therapy (NPWT) combined with lavage system in the treatment of Wagner grade 3-5 diabetic foot ulcers combined with infections. **Methods** The clinical data of 100 patients with Wagner grade 3-5 diabetic foot ulcers combined with infections admitted to our department between January 2016 and January 2020 were retrospectively analyzed. According to the methods of surgical wound management, they were divided into two groups, a combination treatment group treated by NPWT plus a lavage system and a single treatment group receiving NPWT only. Patients were studied for the types of bacterial infection found in the wounds, the amount of time it took for the wound bacterial culture to turn negative, and the status of blood inflammatory indicators, including white blood cell count and C-reactive protein (CRP). Data concerning hospitalization were collected, including the waiting time before the first operation, the number of operations, length of hospital stay, NPWT usage time, and wound closure time. In addition, data concerning patient condition after discharge were also collected, including the duration of out-of-hospital antibiotic use, the final wound healing rate, the final wound healing time, and long-term wound complications, which include wound dehiscence, new ulcer, infection recurrence, readmission, reoperation, and amputation. **Results** There were no statistically significant differences in age, sex, course of disease, lesion side, lesion size and combined diseases between the two groups. Likewise, there was no significant difference in the species and genus, or the composition of bacteria found in the wounds ( $P>0.05$ ). However, the combination treatment group showed better results than the single treatment group did in the amount of time it took for wound bacterial culture to turn negative ( $P<0.05$ ). As for the blood inflammatory indicators, there was no significant difference between the two groups except that the CRP of the combination group decreased more significantly

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than that of the single treatment group did at one week postop. The number of surgeries, length of hospital stay, NPWT use time, and wound closure time were lower in the combination treatment group than those in the single treatment group ( $P < 0.05$ ). However, there was no significant difference in long-term wound complications between the two groups.

**Conclusion** When applying NPWT plus lavage system in the treatment of Wagner grade 3-5 diabetic foot ulcers combined with infection, wound infection can be controlled effectively at an early stage and the amount of time needed for wound bacterial culture to turn negative can also be reduced. In addition, the combination treatment stimulates granulation growth of the wounds to effectively cover the wound at an early stage.

**【Key words】** Negative pressure wound therapy Lavage system Diabetic foot Infection Therapeutic effect

糖尿病足综合征(DFS)是慢性糖尿病的常见并发症,全球每年新发病例可达910万~2610万<sup>[1]</sup>。DFS主要表现为周围神经病变、血管病变和感染等,导致皮肤、肌肉及结缔组织甚至骨骼的慢性进展性病变<sup>[2-3]</sup>。根据目前最常用的糖尿病足损伤的Wagner分类,基于皮肤损伤的深度和是否存在感染和坏疽将足病分为6级,其中Wagner 3~5级糖尿病足合并感染的患者,创面复杂且感染深度已经侵及骨组织,若不积极控制治疗,会发展为足部坏疽或全身性感染,以至于许多患者都采用了预防性截肢的手段避免感染进一步加重<sup>[4]</sup>。目前常用治疗方式包括特殊敷料的局部换药、创面负压治疗(negative pressure wound therapy, NPWT)、NPWT联合生理盐水冲洗、NPWT联合皮肤牵张术等<sup>[5]</sup>。尽管NPWT可以通过将创面与外界隔绝以及充分引流,最大限度地减少坏死组织及炎症渗液在创面中的积聚等作用优化创面,但对于急性广泛的软组织感染,如骨髓炎来说,控制感染的作用有限。本研究回顾并对比分析NPWT联合灌洗系统与单纯使用NPWT治疗Wagner 3~5级糖尿病足合并感染患者的临床疗效。现报道如下。

## 1 对象与方法

### 1.1 研究对象

纳入标准:①四川大学华西医院骨科足踝中心于2016年1月~2020年1月诊断为糖尿病足且Wagner分级为3~5级<sup>[6]</sup>的患者,同时创面培养存在细菌;②采用NPWT治疗;③年龄大于16岁。排除标准:①入院时因严重的并存疾病无法耐受手术者;②创面细菌培养阴性;③患者拒绝手术治疗选择保守换药者;④无法完成至少一年的随访者。

按照上述标准,共纳入100例患者,其中男57例,女43例。年龄40~79岁,平均54.2岁;均为2型糖尿病;糖尿病病程12~35年,平均17.9年;糖尿病足病程3个月~2年,平均1.2年;左足感染43例,右足感染57例;根据Wagner分级分期:3级46例,4级39例,5级15例;0.4<入院时踝肱指

数<1.0;清创术前患者糖化血红蛋白5.3%~9.2%,平均6.93%;入院时糖尿病足创面面积为5.0 cm×2.0 cm~10.0 cm×3.0 cm。本研究按照手术处理创面的方式将研究对象分为联合治疗组(NPWT联合灌洗系统,  $n = 58$ )和单一治疗组(仅使用NPWT,  $n = 42$ )。

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### 1.2 治疗方法

**1.2.1 术前评估及准备** 手术前完善全身情况评估,包括:①心肺功能、营养及代谢情况:完善胸部CT,血气,心肌标志物,心电图,心脏彩超,腹部彩超,下肢血管超声检查,肝肾功,血脂,血糖;②足部感染情况:行足部正、侧、斜位X线照射,足部MRI。监测血中感染指标以及足部创面分泌物的细菌培养及药物敏感实验;③术前宣教:避免患肢过度活动,戒烟戒酒。指导下肢功能训练以及佩戴足部支具。术前应用胰岛素皮下注射调控空腹及三餐后2 h血糖在正常范围内。

**1.2.2 患者分组治疗** 患者入院后经过评估或者治疗达到手术基本要求后,首先进行伤口扩创术,并安置NPWT(单一治疗组)或NPWT联合灌洗系统(联合治疗组)。患者在全麻或者神经阻滞显效后,取仰卧位或者侧卧位,创面常规消毒,首先在创面处切开皮肤以及皮下组织,显露骨组织,探查感染的范围以及感染物的性状,并取感染组织术中再次送细菌培养;若高度怀疑有厌氧菌感染的患者,需在切开感染组织前采用空针抽吸脓液并注射至厌氧菌培养管。然后根据感染的累及范围,并按照可能累及的足部自然间隙(包括足背,1~5跖骨间,足底深浅7个腱膜室),由浅到深逐步探查,清除所有感染的筋膜组织,注意保护各个腱膜室的血管神经丛,完整或者部分切除感染的骨组织,有皮肤变黑坏死的足趾予以截除。应用大量的生理盐水,聚维碘酮等反复冲洗3次,对于怀疑有厌氧菌感染的采用双氧水、生理盐水、聚维碘酮进行冲洗,彻底清除脓性分泌物。单一治疗组采用VAC辅料覆

盖创面; 联合治疗组采用联合灌洗系统进行覆盖。

创面的联合灌洗系统包括抗生素骨水泥链珠、冲洗管、生理盐水和VAC辅料(图1)。首先根据术前创面细菌的药敏实验, 筛选出敏感抗生素, 然后制备成聚甲基丙烯酸甲酯(PMMA)抗生素链珠, 万古霉素可用于MRSA和革兰阳性菌的覆盖, 而妥布霉素可用于革兰阴性菌(包括假单胞菌)的覆盖<sup>[7]</sup>。抗生素与骨水泥按照20%质量浓度与

20 g PMMA(强生, 美国)混合后制备成直径约5 mm一致大小的抗生素骨水泥链珠。创面上安置冲洗管, 然后放置抗生素骨水泥链珠, 采用VAC(KCI, 美国)进行创面覆盖。将负压值设置为100 mmHg(1 mmHg= 0.133 kPa), 采用间歇模式, 吸引5 min、间停2 min, 负压源为配套的负压吸引机, 每天日间冲洗500 mL, 夜间关闭冲洗。5~7 d 更换1次灌洗系统。



图1 NPWT联合灌洗系统

Fig 1 NPWT plus lavage system

The system includes two parts, NPWT system and the lavage system. Panel A shows the NPWT system, which consists of hydrophobic GranuFoam™ dressing and a smart negative pressure therapy instrument. Panel B shows the lavage system consisting of antibiotic cement beads and flushing tubes. As is shown in panels C and D, the drainage tube should be placed on the deep surface of the wound base, and then bone cement chain beads should be put in place. Lastly, the negative pressure auxiliary materials should cover the wound surface. In addition, the flushing pipe should be put in place.

采用扩创和灌洗系统治疗, 通过细菌培养, 确定创面无细菌生长后, 血中炎症指标呈下降趋势后, 检查创面后采用无张力缝合闭合创面, 对于创面无法缝合的患者可以再次更换灌洗系统, 直至创面新鲜肉芽生长后采用游离皮片移植术闭合创面。

### 1.3 观测指标

观察患者创面感染细菌类型, 创面细菌培养转阴的时间、血中炎症指标的情况, 包括白细胞计数和C反应蛋白(CRP)。收集住院期间首次手术术前等待时间, 住院期间手术次数, 住院时间, NPWT使用时间, 创面闭合时间, 以及出院后患者在院外抗生素使用时间, 最终创面愈

合比率, 创面最终愈合时间以及创面并发症, 包括伤口裂开、新溃疡产生、感染复发、再入院、再手术, 截肢等。

### 1.4 统计学方法

对计量资料首先进行方差齐性检验, 符合方差齐性的结果以 $\bar{x} \pm s$ 描述, 采用方差分析进行比较, 多重比较采用Bonferroni法; 计数资料采用例数或例数(%)表示, 使用 $\chi^2$ 检验。P<0.05为差异有统计学意义。

## 2 结果

### 2.1 一般结果

见表1。联合治疗组和单一治疗组患者在年龄、性

别、病程、损伤侧别、病损大小方面差异无统计学意义。两组患者均有较高的比例合并内科疾病,包括高血压、冠心病、下肢动脉缺血、动脉粥样硬化、肾功能不全等,但两组之间差异无统计学意义。

## 2.2 创面细菌培养、炎症指标比较分析

结果见表2。联合治疗组与单一治疗组这两组患者均在创面上培养出了细菌,其中混合感染最为常见,分别占46.6%和35.7%。进行比较,发现两组在阳性细菌、阴性

细菌和混合细菌的比率差异均无统计学意义。但在创面细菌培养转阴时间方面,联合治疗组优于单一治疗组( $P < 0.05$ )。在血中炎症指标中,两组在术前、术后1周以及术后1个月的指标均呈下降趋势,同组的组内下降指标的差异有统计学意义。两组间的白细胞计数比较在术前、术后1周、术后1个月差异无统计学意义;CRP比较术前、术后1个月差异无统计学意义,但在术后1周差异有统计学意义( $P < 0.05$ )。提示联合治疗组可以更早控制创面

表 1 两组患者的一般临床资料对比

Table 1 Comparison of general clinical data between the two groups

Item	Combination treatment group (n=58)	Single treatment group (n=42)	F/ $\chi^2$	P
Age/yr.	56.5±7.8	53.5±8.1	1.763	0.719
(Male/female)/case	34/24	23/19	15.592	0.752
Course of the disease/month	2.9±0.8	3.2±0.9	22.331	0.975
Side (left/right)/case	27/31	16/26	5.651	0.524
Division of injury (forefoot/middle foot/hindfoot)/case	17/12/29	11/14/17	6.651	0.135
Size of the wound	2.0 cm×2.0 cm-7.0 cm×3.0 cm	2.0 cm×2.5 cm-9.0 cm×2.0 cm		
Complicating disease/case (%)				
Hypertension	32 (55.2)	25 (59.5)	0.987	0.788
Coronary artery disease	17 (29.3)	16 (38.1)	1.763	0.614
Lower extremity arterial ischemia	11 (18.9)	19 (45.2)	1.699	0.524
Atherosclerosis	34 (58.6)	22 (52.4)	0.651	0.535
Chronic kidney disease	9 (15.5)	6 (14.3)	1.511	0.675

表 2 创面细菌培养以及转归对比

Table 2 Wound bacterial culture and outcome comparison

Item	Combination treatment group (n=58)	Single treatment group (n=42)	F/ $\chi^2$	P
G <sup>+</sup> positive bacteria/case (%)	19 (32.8)	17 (40.5)	11.977	0.652
G <sup>-</sup> positive bacteria/case (%)	12 (20.7)	10 (23.8)	1.623	0.776
Mixed bacteria/case (%)	27 (46.6)	15 (35.7)	1.7542	0.652
Time of bacterial culture showing sterility/d	7.5±2.8	12.3±3.6	0.223	0.012
Pre-operation				
White blood cell count/( $\times 10^9 L^{-1}$ )	11.2±2.2	10.9±1.7	1.776	0.655
CRP/(mg/L)	45.7±7.9	39.7±8.2	2.342	0.234
1 week post-op				
White blood cell count/( $\times 10^9 L^{-1}$ )	7.2±1.6	7.9±1.4	0.965	0.782
CRP/(mg/L)	9.7±3.3	15.2±4.3	0.823	0.032
1 month post-op				
White blood cell count/( $\times 10^9 L^{-1}$ )	5.4±2.1	5.9±1.6	0.234	0.771
CRP/(mg/L)	4.7±0.9	4.9±0.8	0.221	0.598
Bonferroni correction*	P=0.001	P=0.001		

\* Results of the intragroup multiple comparisons of white blood cell count and CRP at different points of time.

感染,降低全身的炎症反应。

### 2.3 创面愈合结果及转归比较分析

结果见表3。联合治疗组与单一治疗组在住院期间首次手术术前等待时间比较,差异无统计学意义,但从住院期间手术次数、住院时间、NPWT使用时间、创面闭合时间比较来看,联合治疗组的指标均低于单一治疗组,差异有统计学意义( $P < 0.05$ )。这说明NPWT联合灌洗系统,可以更有效地控制创面感染,促进创面愈合,减少手术次数,降低住院时间。对于创面的最后愈合方式,无论

是采用直接缝合还是游离皮片移植覆盖创面,两组差异无统计学意义。

### 2.4 院外创面远期并发症比较分析

结果见表4。联合治疗组与单一治疗组这两组患者在院外抗生素使用时间、最终创面愈合比率、创面最终愈合时间比较,差异无统计学意义。从创面并发症来看,包括伤口裂开、新溃疡产生、感染复发、再入院、再手术及截肢,两组差异无统计学意义。表明NPWT联合灌洗系统并没有在预防远期并发症方面具有更大的优势。

表3 创面结果对比

Table 3 Comparison of the outcomes of the wounds

Item	Combination treatment group (n=58)	Single treatment group (n=42)	$F/\chi^2$	P
Surgeries during admission/d	3.6±2.2	4.2±2.3	0.992	0.932
Number of surgeries	2.2±0.9	3.3±1.2	1.763	0.042
Time of NPWT/d	14.7±7.1	19.6±7.9	23.221	0.031
Length of stay/d	27.2±9.2	31.8±8.1	17.111	0.029
Time to surgical closure/d	13.11±5.3	16.5±4.9	21.107	0.015
Wound status at discharge/case (%)				
Surgically closed	42 (72.4)	31 (73.8)	0.972	0.211
Wound covered	16 (27.6)	10 (23.8)	0.234	0.091
Wound open	0	1 (2.4)		0.000

表4 伤口并发症及出院后预后的比较

Table 4 Comparison of wound complications and prognosis after discharge from hospital

Item	Combination treatment group (n=58)	Single treatment group (n=42)	$F/\chi^2$	P
Duration of antibiotics/d	32.4±9.2	34.1±8.8	0.921	0.127
Wound healed at the end of study/case (%)	56 (96.6)	39 (92.6)		
Time to heal/d	47.5±12.9	57.5±16.9	23.467	0.223
Wound dehiscence surgically closed/case (%)	1 (1.7)	2 (4.8)		
New ulcer formation/case (%)	3 (5.2)	3 (7.1)	2.789	0.112
Reinfection/case (%)	4 (6.7)	5 (11.9)	0.123	0.178
Hospital readmission foot/case (%)	4 (6.7)	5 (11.9)	0.324	0.221
Subsequent surgeries/case (%)	3 (5.2)	5 (11.9)	0.983	0.143
Incision and drainage/case (%)	3 (5.2)	5 (11.9)	0.864	0.092
Amputation foot/case (%)	1 (1.7)	2 (4.8)	0.345	0.021
Amputation leg/case (%)	0	1 (2.4)	0.667	0.001

Amputation refers to the highest level of amputation performed during index hospitalization or during the follow-up period.

## 3 讨论

糖尿病足的患者常合并感觉神经病变、外周动脉病变、营养不良、免疫病变及血糖控制不佳<sup>[2]</sup>。特别是Wagner 3~5级糖尿病足合并感染的患者因感染侵及骨

组织,甚至伴有坏疽,这使得控制感染,挽救肢体具备更大的挑战性。足骨的慢性骨髓炎的治疗因病因不同而异,但治疗的共同点是多模式手术,包括手术清创、全身抗生素治疗和局部抗生素治疗。根据感染持续时间、致病病原体类型、软组织状态和患者健康状况的不同,可采

用一期或二期手术治疗,治疗方案的选择应根据患者病情而定。对于有全身症状的严重感染、有骨及关节组织损伤的感染,需要分期手术治疗<sup>[7]</sup>。本研究中的两种治疗方案均是两阶段多模式治疗策略,其中第一阶段主要目的是控制感染,主要包括扩创手术和植入局部抗生素载体。在第二阶段的目的则是覆盖创面,主要包括去除局部抗生素载体、游离皮片移植、皮瓣转移、皮肤牵张等等。糖尿病足创面修复的传统办法主要依靠各种药物(抗感染药物、外用生长因子制剂)及敷料(水胶体、水凝胶、藻类敷料等)<sup>[8]</sup>。而NPWT是一种具有一定创新性的治疗理念,它极大地改变了复杂伤口的治疗方法。根据文献报道,在糖尿病足的创面中,有两项随机临床试验显示NPWT与标准的手术相比,NPWT的愈合率更高,愈合速度更快,截肢更少<sup>[9-10]</sup>。在NPWT的同时添加抗菌冲洗,在糖尿病合并足部感染患者中具备更大的治疗潜力<sup>[11]</sup>。在本研究来看,是否联合使用灌洗系统,NPWT都具备较好地控制感染的能力,最终促进创面愈合。从血中炎症指标来看,两组在术前、术后1周以及术后1个月的指标均具备显著的下降趋势;但NPWT联合灌洗系统治疗时,CRP在术后早期下降得更为明显,进一步表明联合治疗时控制感染方面的优势更为明显,它可以大大加快创面的愈合时间,控制感染的同时,又能加快创面的肉芽生长。由于Wagner 3~5级糖尿病足合并感染的患者是一个具有多种合并症的异质性人群,包括营养不良、肾脏疾病、外周动脉疾病和血糖控制不佳,因此目前缺乏在糖尿病合并足部感染患者中比较NPWT联合和不联合抗菌冲洗疗效的前瞻双盲随机对照试验。尽管本研究发现联合灌洗系统的NPWT能早期有效控制感染,能够降低住院日,但同时也发现对于远期并发症方面,并没有表现出过多的优势。

那么为什么灌洗系统可以促进感染的控制呢?在一个猪模型的基础实验表明,与传统NPWT或标准敷料相比,NPWT可显著降低细菌培养数量<sup>[12]</sup>。DAVIS等<sup>[13]</sup>认为在使用NPWT的同时使用生理盐水冲洗的伤口中,细菌培养量显著减少。尽管DAVIS团队在后续的糖尿病足感染患者的一项随机临床试验中,并没有发现传统NPWT和NPWT+生理盐水同期冲洗两种治疗方式在伤口愈合、不良事件或愈合时间有任何差异。但有几项回顾性临床研究在混合病因感染创面患者中比较了NPWT联合抗菌冲洗和传统NPWT,结果表明NPWT改善了临床结局<sup>[14-16]</sup>。因此可见局部抗生素的使用在控制感染方面具有一定的作用。对于抗菌效果,重要的是局部抗生素浓度超过病原体的最低抑菌浓度(MIC)。对于抗生素的选择,重要

的是要长时间超过MIC或达到最高浓度,因为抗生素具有不同的活性模式。一些抗生素(大环内酯类、 $\beta$ -内酰胺类抗生素和克林霉素)靠时间依赖性发挥杀伤作用,而其他抗生素(氨基糖苷类、喹诺酮类和万古霉素)则依赖于浓度达到高于MIC的最高可能的局部浓度。而后者是我们选择的主要抗生素类型。

聚甲基丙烯酸甲酯(polymethylmethacrylate, PMMA),也称为骨水泥或丙烯酸骨水泥,是一种被广泛接受的用于局部抗生素递送的载体材料,并且可以超过所需的MIC<sup>[17]</sup>。这种所谓的载抗生素PMMA或载抗生素骨水泥有不同的应用形式,通常作为珠(或珠链)或填充占位材料。但是这种材料是通过将预聚体粉末与液体单体混合,形成快速凝固的面团,在此过程中温度达到60~80℃。高固化温度由PMMA的放热自由基聚合引起,这要求骨水泥中使用的抗生素具有热稳定性,以保持其功能。这一热稳定性要求最终限制了可纳入PMMA的抗生素的范围。氨基糖苷类抗生素(如妥布霉素和庆大霉素)是与PMMA兼容且满足这一要求的少数几类抗生素之一。本研究中主要采用万古霉素、庆大霉素和妥布霉素搭载在PMMA上,制备成大小约5 mm的链珠,主要是因为外科医生自制的抗生素骨水泥链珠不仅可以显著节省成本和时间,还可以提高链珠的质量。研究发现,负载抗生素的骨水泥链珠可防止细菌的早期细菌定植和生物膜形成,从而可能降低总体感染率<sup>[18]</sup>。但临床上有些细菌,特别是G<sup>-</sup>杆菌对氨基糖苷类抗生素天然耐药,这也是其固有的局限性。

MOOJEN等<sup>[19]</sup>发现载抗生素骨水泥链珠在2~3 d内达到最大抗生素释放量,半衰期在6~10 d范围内。1周后会低于MIC,而载抗生素骨水泥的药物浓度对MIC也有一定的影响。文献报道在急性感染的治疗中,使用超过5%质量浓度的药物/水泥,而用于预防性应用的药物/水泥的浓度低于5%<sup>[20]</sup>。低剂量的抗生素掺入可能会在长时间内导致抗生素耐药细菌的产生,但高剂量的抗生素已被证明对骨水泥的抗压和抗剪切力学性能有不利影响<sup>[21]</sup>。适当的剂量由外科医生决定。本研究中载抗生素骨水泥不作为硬性支撑材料,因此我们采用了20%质量浓度的骨水泥。

本研究也存在一定的不足,首先是本研究采用回顾性病例对照分析,由于患者的合并疾病,复杂的糖尿病创面,让治疗过程存在较多的偏倚,大大降低了判断单一治疗是否影响临床结局的可信度。其次,选取的病例在年龄、下肢血管条件方面因为病例数量没有进行分组分析。因此,未来需要探索更为严谨的标准的临床前瞻随

机对照研究对本研究的结论进一步验证。

\* \* \*

**利益冲突** 所有作者均声明不存在利益冲突

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