TIME TO FIRST NEGATIVE CULTURE FOLLOWING DEBRIDEMENT REAMING AND IRRIGATION FOR CHRONIC OSTEOMYELITIS: A LOOK AT THE LAUTENBACH METHOD

P. Ntombela, MBChB (UKZN), FC Orth (SA), MMed (Wits), PG Diploma Health Research (Oxford), Fellow in Tumour and Sepsis Unit, Charlotte Maxeke Johannesburg Academic Hospital, University of the Witwatersrand, 7 York Road Parktown, Johannesburg, South Africa, **Z. Linda,** MBBCh (Wits), FC Orth (SA), Head of Tumour and Sepsis Unit Charlotte Maxeke Johannesburg Academic Hospital, University of the Witwatersrand, 7 York Road Parktown, Johannesburg, South Africa, **O. Phakathi,** MBChB (UCT), Senior Registrar, University of the Witwatersrand, 7 York Road Parktown, Johannesburg, **T. Phiri,** MBBCh (Wits), FC Orth (SA), MMed (Wits). Fellow in Tumour and Sepsis Unit Charlotte Maxeke Johannesburg Academic Hospital, University of the Witwatersrand, 7 York Road Parktown, Johannesburg, South Africa and **M. Kgagudi,** MBBCh (WITS), FC Orth (SA), MMed (Wits), Head of Tumour and Sepsis Unit, Chris Hani Baragwanath Academic Hospital, University of the Witwatersrand, 7 York Road Parktown, Johannesburg, South Africa

Correspondence to: Dr. Philani Ian Ntombela, University of the Witwatersrand 7 York Road Parktown, Johannesburg, South Africa, 2193. Email: philani2086@gmail.com

ABSTRACT

Background: Chronic osteomyelitis poses a challenge for the patient and the treating surgeon. Lautenbach described an adjuvant method entailing the insertion of a double-lumen tube system, for local antibiotic delivery and dead space management.
Objective: The aim of the study was to establish the time it takes to achieve the first negative culture after the Lautenbach procedure for the treatment of chronic osteomyelitis.
Methods: We undertook a retrospective record review of patients who underwent the Lautenbach procedure from 2018 to 2021. The primary outcome was time to the first negative, fluid or tissue, culture after the procedure. Secondary outcomes were, time to 3rd negative culture, wound/sinus status, pain Visual Analogue Scale (VAS), recurrence rate and prevalence of Methicillin Resistant *Staphylococcus Aureus* (MRSA).
Results: Thirty eight patients were included, 27 (71.1%) males and 11 (28.9%) females. The median age was 32 years. The median time to the first negative culture was 6 days while that for the time to the 3rd negative culture result was 8 days. The median pain VAS was 3 points and the recurrence rate was 24%. There was a 10.5% rate of MRSA.
Conclusion: The Lautenbach procedure is still an effective option. However, the recurrence rate remains relatively high with majority of the patients achieving symptom resolution (pain and draining sinus). Treating surgeons should still be vigilant of MRSA and its treatment thereof.

Key words: Lautenbach, Chronic osteomyelitis, Dead space, Antibiotics, Sequestrum

INTRODUCTION

Chronic Osteomyelitis (COM) is a challenging condition to treat. It leads to destruction and necrosis of bone (1). It is marked by progressive inflammation that distorts the architecture of bone (1). Multiple treatment regimens exists for this condition but there is limited level I evidence for gold-standard of treatment (2). The principles of treatment for COM are well understood, the surgical principles include debridement of dead bone, dead space, and soft-tissue management (3). In the literature there are many studied options for dead space management (4) but in our institution we employ the Lautenbach method. This entails the use of a double-lumen suction-irrigation system placed in the bone canal (3). It serves to manage the dead space and as a local delivery system of antibiotics.

Despite the available methods, the recurrence rate remains high at 20 - 30% (5). A success rate of 85% has been found in some studies (3). Regardless of treatment plan and institutional preference, patients are often admitted for long periods in hospital, subject to potential side effects from antibiotics and developing antibiotic resistance.

The study aimed to evaluate the average time it takes to achieve the first negative culture result after the Lautenbach method for the treatment of long bone Chronic Osteomyelitis (COM). This was described in Lautenbach's 1975 publication for the treatment of long bone COM (6). Weber and Lautenbach subsequently described this method in their 1985 paper for the treatment of infected total hip replacement (7).

MATERIALS AND METHODS

Upon approval by our institution's human research ethics committee (M221075) we undertook a retrospective study of patients treated by the Lautenbach method for long bone COM for the period of the year 2018 to 2021. A minimum follow-up time of 12 months was set for the study. The study included both first time and repeat procedures, children, adults and both upper limb and lower limb COM. Patients who defaulted follow-up before 12 months post-operatively, peri-Prosthetic Joint Infection (PJI) or flat bone COM and those with incomplete medical records were excluded. Studied parameters included patient demographics, involved anatomical site, time to the first negative culture, time to the 3rd negative culture, wound status, the rate of Methicillin Resistant *Staphylococcus Aureus* (MRSA) and recurrence rate within 12 months of the procedure. Recurrence was defined as need for a repeat procedure within the 12-month follow-up period. The Lautenbach procedure is used for any Cierny and Mader stage (anatomic component) of COM depending on the symptomatology and the host type. We selected host type A and B with unresponsive symptoms to conservative means of treatment i.e., draining sinus. The Lautenbach system is an adjuvant double-lumen suction-irrigation system for dead space management and local antibiotic delivery after a thorough Debridement, Reaming and Irrigation (DRI) plus sequestrectomy. Intra-operatively deep specimens are collected. The system is left in the bone canal for 2 days before the first specimen can be collected. Our local protocols allow for the use of gentamycin and amoxicillin/clavulanic acid empirically. After the first specimen, specimens are collected every second day until three consecutive culture-negative specimens are documented. At this point the system is removed and culture-sensitive antibiotics are initiated. The patient is kept on these antibiotics for 6 weeks post-operatively either as an outpatient or inpatient based on the preferred route of antibiotic administration as per sensitivity. The first outpatient review is usually 2 to 3 weeks post-surgery for wound evaluation. All procedures were performed by the senior author (ZL) or by a fellow in the unit under his supervision.

RESULTS

Thirty eight patients met the inclusion criteria, 11 (28.9%) females and 27 (71.1%) males. The median age (inter-quartile range) was 32 [14, 42] years. The recorded median (IQR) time to the first negative culture result was 6 [2, 9] days while that for the time to the 3rd negative culture result was 8 [6,13] days. The median (IQR) pain Visual Analogue Scale (VAS) was 3 [2,4]. Thirty four (89%) patients had healed wounds at the time of follow-up and only 4 (11%) presented with a draining sinus. The rate of MRSA isolation was 10.5%. Recurrence of disease within 12 months of the index procedure occurred in 9 (24%) patients and Table 1 compares the cohort with recurrence to that of ones without. Fifty percent of the cases involved the femur bone, followed by tibia with 26.3% (Figure 1). Figure 2 shows the affected site for each anatomical region while Table 2 shows the organisms isolated. Seventeen percent of organisms were resistant to amoxicillin/clavulanic acid while 24.4% were resistant to ampicillin (Figure 3). Table 3 shows the profile of the nine patients that presented with recurrence.

Table 1

Patient demographics and outcomes of interest for the non-recurrence and recurrence group

	Recurrence (9/38; 24%)			
	No (N=29)	Yes (N=9)	Total (N=38)	P-value
Age				0.046
Median (Inter-Quartile Range)	30(13,39)	41 (40,48)	32 (14,42)	
Days to 1st -ve				0.692
Median (Inter-Quartile Range)	6(6,9)	4(2,8)	6(2,9)	
Days to last -ve				0.821
Median (Inter-Quartile Range)	9(6,13)	7(6,15)	8(6,13)	
Pain VAS				0.039
Median (Inter-Quartile Range)	3(2,3)	4(3,4)	3(2,4)	
Gender				1.000
Female	8(27.6%)	3(33.3%)	11(28.9%)	
Male	21(72.4%)	6(66.7%)	27(71.1%)	
Wound status				0.064
Healed	29(100%)	5/9(55.5%)	34/38(89%)	
Oozing	0(0%)	4/9(44.4%)	4/38(11%)	
Cloxacillin resistance				1.000
NR	11(37.9%)	4(44.4%)	15(39.5%)	
Sensitive	15(51.7%)	4(44.4%)	19(50.0%)	
MRSA occurrence	1(3.5%)	2(7%)	3(10.5%)	

Table 2

Organisms isolated

Organism	No. (%)
Staphylococcus aureus	14 (37)
Staphylococcus aureus & others	4(12)
Gram negatives	8(24)
Polymicrobial (without *Staphylococcus aureus*)	5(15)

Table 3

The profile of patients with disease recurrence

	Age	Gender	Site	C+M	Organism/s	Resistance	HIV status
P1	41	M	Left femur	III	*Kocuriakristinae, SA, Klebsiella, PM*	Ampicillin, Ciprofloxacillin	Negative
P2	55	M	Right femur	IV	*Enterobacter A, Salmonella, Klebsiella, PM*	Augmentin, Ertepenem, Ciprofloxacillin	Negative
P3	37	F	Right femur	IV	*SA*	Ampicillin	Negative
P4	45	F	Right tibia	IV	*Gram negative bacillus*	None	Positive
P5	40	M	Right femur Right tibia	III	*PM, MRSA*	Ampicillin, Ciprofloxacillin, Rifampicin	Negative
P6	48	M	Right tibia	IV	*Pseudomonas aeruginosa*	Augmentin	Positive
P7	15	F	Right humerus Right femur	III	*SA*	Ampicillin	Negative
P8	18	M	Right tibia	IV	*Streptococcus dysgalactiae*	Augmentin	Negative
P9	52	M	Right tibia	III	SM	Augmentin, Ciprofloxacillin	Positive

M: male, F: Female, SA: Staphylococcus Aureus, PM: Proteus Mirabilis, Enterobacter A: enterobacteraero genes, SM: Serratia Marcescens, C+M: Cierny and Made, MRSA: Methicillin Resistant Staphylococcus Aureus

Figure 1

Affected bone

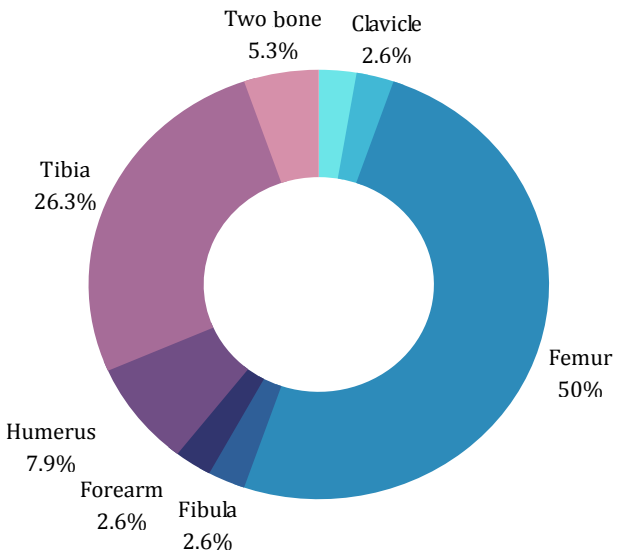
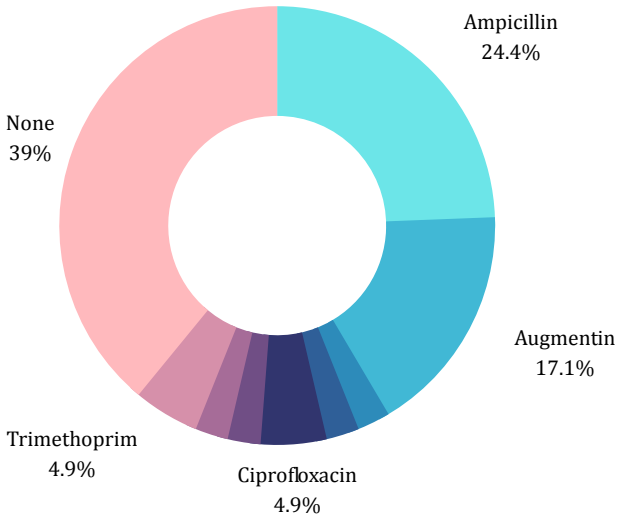


Figure 2

Resistance profile



DISCUSSION

Jorge *et al.* (8) studied a retrospective cohort to identify factors that predispose to disease recurrence. Old age and an infection with *Pseudomonas aeruginosa* were identified as risk factors. Pozo *et al.* (5) investigated the same question and concluded with the identification of different factors. His factors included a need for a muscular flap and osteomyelitis extending beyond 3 months (5). Leung *et al.* (9) found a recurrence rate of 12% in their study. The median hospital stay in a study by Grey *et al.* (10) was 6 days (IQR 4-7 days) and this was looking at the use of continuous irrigation system (modified Lautenbach) for anatomical type I fracture-related COM. We are unaware of any study that addresses our study aim in comparison to the available literature looking into duration of hospital stay and not the time it takes to achieve the first negative culture result. This is an important question as it is the first step in the sequence of events to which define treatment success for the Lautenbach method. Equally important is the time it takes to achieve the 3rd consecutive negative culture result (treatment success). This has a direct effect on the number of days spent in hospital and health resource utilization. Our patient cohort has a longer hospital stay compared to that of Grey *et al.* (10), purely because our institution still uses the original described Lautenbach method which in its nature requires a longer hospital stay. Hashmi *et al.* (11), recorded a mean hospital stay of 38 days (26 – 78) in their study but worth noting is that they used two systems in one medullary canal and some of their patients also had an additional system in the soft-tissues. This prolonged their length of stay in hospital compared to our cohort where we used only one system per canal for all patients. Their recorded mean length of treatment was 27 days with a non-recurrence rate of 75% using this method. There are many options used for dead space management, but none has been shown to be superior to the other (4). The choice is based on patient profile, local protocols, surgeon preference and affordability. Our rate of MRSA isolation was 10.5% while that recorded by Hashmi *et al.* (11) was 5.8%. There is a recorded rise in the rate of MRSA since the early 2000's and such a finding in our cohort is in keeping with existing literature (12). Also of concern is the high rate of gram-negative bacteria (24%) that were cultured in our study population. Mthethwa and Marais (13) reported a 26% rate of gram-negative cultures and made a significant link between this, and COM caused by fracture-related infection. Such an association could not be statistically made in the index study, nor could it be linked to the patients' physiological status. Another proposed explanation is that these hospital-acquired organisms could have been introduced through the suction-irrigation system during treatment. However, there is no evidence of this as there was no change in organism profile from the first specimen compared with the last collected specimen. Majority of our patients had cultured *Staphylococcus Aureus* (SA) which was 37% of the cohort. *Staphylococcus aureus* is the most isolated organism in COM and our study does not offer any new finding in this regard (14-16). Chronic osteomyelitis is a significantly challenging condition to manage and has a high recurrence rate (17-21). The recurrence rate in this study was 24% and although the evaluation of the factors associated with this was beyond the objectives of this study, future work is aiming to study this in a large sample size. Some of the reported factors include old age, intra-operative blood transfusion, infection due to *P. aeruginosa* and need for a muscular flab (5,8). Some of the identified risk factors of interest include age, gender, duration of infection, C-Reactive Protein to Estimated Sedimentation Ratio (CRP/ESR) index, neutrophil-lymphocyte ratio, Cierny and Mader grade, site, previous surgery, and Body Mass Index (BMI).

CONCLUSION

The median time duration of the treatment of long bone chronic osteomyelitis using the Lautenbach method is acceptable and this remains an effective procedure. The rate of recurrence of COM after surgical treatment and within 12 months is still high and there is no definitive, widely accepted definition of treatment success. Future work should incorporate identifying a scientifically reproducible criteria for the prediction of recurrence within 12 months of surgical treatment.

Declarations

Conflict of interest statement: Philani Ntombela declares that he has no conflict of interest. No research grants have been received by any of the authors for this work.

Funding sources: No funding was received for the purposes of performing this study.

REFERENCES

1. Birt, M.C., Anderson, D.W., Bruce, T.E. and Wang, J.Osteomyelitis: recent advances in pathophysiology and therapeutic strategies. *J Orthop*. 2017; **14**:45–52.
2. Arshad, Z., Lau, E.J., Aslam, A., Thahir, A. and Krkovic, M. Management of chronic osteomyelitis of the femur and tibia: a scoping review. *EFORT Open Rev*. 2021; **6**(9):704-715. doi: 10.1302/2058-5241.6.200136. PMID: 34667641; PMCID: PMC8489473.
3. Caesar, B.C., Morgan-Jones, R.L., Warren, R.E., Wade, R.H., Roberts, P.J. and Richardson, J.B. Closed double-lumen suction irrigation in the management of chronic diaphyseal osteomyelitis: long-term follow-up. *J Bone Joint Surg Br*. 2009; **91**(9):1243-48. doi: 10.1302/0301-620X.91B9.21768. PMID: 19721055.
4. Pincher, B., Fenton, C., Jeyapalan, R., Barlow, G. and Sharma, H.K. A systematic review of the single-stage treatment of chronic osteomyelitis. *J Orthop Surg Res*. 2019; **14**(1):393. doi: 10.1186/s13018-019-1388-2. PMID: 31779664; PMCID: PMC6883574.
5. Garcia Del Pozo, E., Collazos, J., Carton, J.A., Camporro, D. and Asensi, V. Factors predictive of relapse in adult bacterial osteomyelitis of long bones. *BMC Infect Dis*. 2018; **18**(1):635. doi: 10.1186/s12879-018-3550-6. PMID: 30526540; PMCID: PMC6286499.
6. Weber, F.A. and Lautenbach, E.E. Revision of infected total hip arthroplasty. *Clin Orthop Relat Res*. 1986; **211**:108-115. PMID: 3769249.
7. Lautenbach, E. Proceedings: Chronic osteomyelitis: Irrigation and suction after surgery. *J Bone Joint Surg Br*. 1975; **57**:259.
8. Jorge, L.S., Chueire, A.G., Fucuta, P.S., *et al*. Predisposing factors for recurrence of chronic posttraumatic osteomyelitis: a retrospective observational cohort study from a tertiary referral center in Brazil. *Patient Saf Surg*. 2017; **11**:17. https://doi.org/10.1186/s13037-017-0133-1.
9. Leung, A.H., Hawthorn, B.R. and Simpson, A.H. The effectiveness of local antibiotics in treating chronic osteomyelitis in a cohort of 50 patients with an average of 4 years follow-up. *Open Orthop J*. 2015; **9**:372-378. doi: 10.2174/1874325001509010372. PMID: 26322143; PMCID: PMC4549894.
10. Grey, J.P., Burger, M., Marais, L.C. and Ferreira, N. Continuous irrigation as dead space management for fracture-related type 1 intramedullary chronic osteomyelitis. *J Limb Lengthen Reconstr*. 2022; **8**:67-72.
11. Hashmi, M.A., Norman, P. and Saleh, M. The management of chronic osteomyelitis using the Lautenbach method. *J Bone Joint Surg Br*. 2004; **86**(2):269-275. doi: 10.1302/0301-620x.86b2.14011. PMID: 15046445.
12. Arnold, S.R., Elias, D., Buckingham, S.C., *et al*. Changing patterns of acute hematogenous osteomyelitis and septic arthritis: emergence of community-associated methicillin- resistant Staphylococcus aureus. *J Pediatr Orthop*. 2006; **26**:703–708.
13. Mthethwa, P.G. and Marais, L.C. The microbiology of chronic osteomyelitis in a developing world setting. *SA Orthop. J.* [Internet]. 2017; **16**:39-45.
14. Walter, G., Kemmerer, M., Kappler, C. and Hoffmann, R. Treatment algorithms for chronic osteomyelitis. *DtschArztebl Int*. 2012; **109**: 257–264.
15. Kavanagh, N., Ryan, E.J., Widaa, A., *et al*. Staphylococcal osteomyelitis: disease progression, treatment challenges, and future directions. *Clin Microbiol Rev*. 2018; **31**:e00084–00017.
16. Lew, D.P. and Waldvogel, F.A. Osteomyelitis. *N Engl J Med*. 1997; **336**:999–1007.
17. Chihara, S. and Segreti, J. Osteomyelitis. *Dis Month*. 2010; **56**:5–31.
18. Tice, A.D., Hoaglund, P.A. and Shoultz, D.A. Outcomes of osteomyelitis among patients treated with outpatient parenteral antimicrobial therapy. *Am J Med*. 2003; **114**:723–728.
19. Tice, A.D., Hoaglund, P.A. and Shoultz, D.A. Risk factors and treatment outcomes in osteomyelitis. *J Antimicrob Chemother*. 2003; **51**:1261–68.
20. Lipsky, B.A., Berendt, A.R., Deery, H.G., Embil, J.M., Joseph, W.S., Karchmer, A.W., *et al*. Diagnosis and treatment of diabetic foot infections. *Plast Reconstr Surg*. 2006; **117** (7 Suppl): 212S–38S.
21. Arias, A.C., Tamayo, B.M.C., Pinzón, M.A., Cardona A.D., Capataz T.C.A. and Correa, P.E. Differences in the clinical outcome of osteomyelitis by treating specialty: Orthopedics or infectology. *PLoS One*. 2015; **10**:e0144736.