

BOAST 4 Guidelines - Literature Review and Recommendations

Athanasios Serlis^{1*}, Panagiotis Poullos², Grigoris Bolgouras³,
Panagiotis Konstantinou⁴ and Georgios Konstantopoulos¹

¹Royal London Hospital, Orthopaedic Department, Barts NHS Trust, United Kingdom

²Newham University Hospital, Orthopaedic Department, Barts NHS Trust, United Kingdom.

³Larnaca General Hospital, Orthopaedic Department, United Nations, Cyprus

⁴General Hospital of Thessaloniki G.Gennimatas, Greece

***Corresponding Author:** Athanasios Serlis, Royal London Hospital, Orthopaedic Department, Barts NHS Trust, United Kingdom.

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Abstract

Open fractures constitute serious injuries which range from small puncture wounds trauma to high energy traumatic injuries. The British Orthopaedic Association and British Association of Plastic, Reconstructive and Aesthetic Surgeons have established evidence-based instructions for the assessment and management of open fractures in the pre-hospital and hospital setting. BOAST 4 (British Orthopaedic Association Standards for Trauma 4) guidelines have introduced nineteen instructions which are aiming to address the problems that arise in the management of open fractures. Additionally, these guidelines provide detailed guidance to the clinicians regarding the decision-making process and raise awareness for the most common complications in order to enhance patients' care and safety.

This article aims to review the evidence of BOAST 4 guidelines and suggest modifications based on the current literature.

Keywords: Open Fracture; BOAST Guidelines; Management; Literature Review

Introduction

Open fractures constitute serious injuries which range from small puncture wounds trauma to high energy traumatic injuries. They are associated with severe damage to the skin, soft tissues and neurovascular structures and have a significant impact on patients' life. More specifically, the majority of these injuries, regardless of their anatomical location, increase the morbidity and mortality rates, while their complications affect the socio-financial and psychological status of patients and their families. The complexity of open fractures makes their management challenging; thus, the cooperation and coordination of the emergency and hospital services is required in order to mediate their devastating effects. Well-structured trauma systems with appropriate guidelines and a multidisciplinary team approach are essential in the manage-

ment process of open fractures so as to minimise infection rates and achieve better results.

The British Orthopaedic Association and British Association of Plastic, Reconstructive and Aesthetic Surgeons have established evidence-based instructions for the assessment and management of open fractures in the pre-hospital and hospital setting. BOAST 4 (British Orthopaedic Association Standards for Trauma 4) guidelines have introduced nineteen instructions which are aiming to address the problems that arise in the management of open fractures. Additionally, these guidelines provide detailed guidance to the clinicians regarding the decision-making process and raise awareness for the most common complications in order to enhance patients' care and safety.

Antibiotic prophylaxis

One of the most critical steps in the management of open fractures is the prevention of the infection, especially in high-grade fractures with significant contamination. British Orthopaedic Association has suggested early administration of intravenous antibiotics, within the first hour of the injury. Their recommendation is based on four cohort studies, which however are of low quality and have insufficient data to support that the early antibiotic administration (<1 hr) is reducing the risk of infection. Additionally, three of the included studies reported that the timing of antibiotics was irrelevant to the final outcome. Weber, *et al.* supported that the infection rates were associated with the injury grade, while there were statistically non-significant results for the effect of early antibiotic administration [1]. Despite the large sample size (686 patients) and the adequate follow-up period, this study had severe limitations. To be more specific, one hundred and three patients received antibiotics prior to their admission, but there are no available data for the timing of the administration and this fact might have affected the overall results.

Hull and colleagues tried to identify the relationship between surgical debridement and infection rates [2]. Antibiotics were given until wound closure, but the results were non-significant regarding their effectiveness in the reduction of deep infection rates. The large sample size and appropriate follow up rate support the results of this study. However, authors failed to analyse the type of antibiotics, the time of wound coverage and the debridement technique. Therefore, the results of this study need to be reviewed with caution. Lack, *et al.* recommended that prompt antibiotic administration decreases the deep infection rates in high-grade injuries [3]. This study was the first to support this evidence, but its results are questionable because of the multiple variables that might have affected the results and the inadequate follow-up period. Also, considering the fact that only Grade III open tibial fractures were included, the above results can not be applied for all fracture types.

The appropriate duration of antibiotic prophylaxis has been reviewed in multiple studies, but the evidence in the literature, which supports the efficacy of early administration is limited. The application of local antibiotics in the management of open fractures is a controversial topic which has been analysed over the last decades. Antibiotic beads fill anatomical defects after surgical debridement and provide higher local concentration rates compared to the intravenous antibiotics. Morgenstern, *et al.* showed a 12% reduction in the infection rates when local and systemic antibiotics are be-

ing used in the treatment of open fractures [4]. This study had a large sample size and provided statistically significant results for all fracture grades. However, half of the participants did not have an appropriate follow-up period and the quality of the included studies was low.

Additionally, Keating and colleagues supported that antibiotic beads could be used as an additional tool in the management plan of open fractures [5]. However, their results can not be generalised to the entire population due to the small sample size and the fact that only tibia fractures were included in the study. The implementation of local antibiotics in the BOAST 4 guidelines would provide significant advantages in the management of open fractures, but more systematic reviews are required to provide sufficient data.

Trauma centre and orthoplastic care

British Orthopaedic Association has highlighted the necessity for treating the long bone, midfoot and hindfoot open fractures in a trauma unit that can provide joint orthopaedic and plastic surgical management. A multidisciplinary team approach is of paramount importance in the treatment of these injuries in order to achieve better results and mitigate secondary complications. After the initial resuscitation of the patient, the antibiotic prophylaxis and the immobilisation of the limb, patients with open fractures need to be transferred to a specialist centre with the available resources and experienced personnel.

The study that was reviewed by the Guideline Development Group was conducted by Naique and colleagues. Authors showed that the management of these injuries at local centres is associated with higher infection rates, as well as more flap failures and delayed amputations compared to trauma units [6]. Despite the statistically significant results, the conclusions of this study should be treated with caution due to the small sample size, the limited number of Grade IIIB injuries and the lack of report of the soft tissue damage. This practice is supported by Gopal, *et al.* who showed that the aggressive management of high-grade open fractures in trauma centres lead to better outcomes [7]. Notwithstanding the limited sample size and the cases which deviated from the protocol, this study emphasised the need for urgent transfer of open fractures in primary centres.

Limb salvage-delayed amputation

Undoubtedly, the management of mangled limb is very challenging and clinicians usually face the dilemma between limb salvage or amputation, considering patient's factors and associated injuries.

Preservation of life should be the first priority, but in the decision-making process of amputation or reconstruction, several teams should be involved. British Orthopaedic Association has recommended that the orthopaedic and plastic surgeons should liaise with patients and their families in order to achieve the most favourable result and avoid unnecessary complications. The Guideline Development Group reviewed twenty-three studies so as to implement a precise prediction tool which will help surgeons to identify early patients whose limb could be salvaged or amputated. However, the included studies had a significant risk of bias and poor quality; thus, the decision of limb salvage or amputation can not be justified by the use of the scoring systems. More specifically, Kumar, *et al.* showed that the MESS (Mangled extremity severity score) has high sensitivity and specificity, but the decision for amputation or reconstruction was based on other factors [8].

Furthermore, the study from Fagelman and colleagues failed to provide sufficient data for the use of MESS in patients with amputation and the limited follow-up period constitutes a possible source of bias [9]. Slauterbeck, *et al.* supported that the MESS score is an essential tool for the clinicians in the management of mangled extremity [10]. However, this study has a significant risk of bias, as there are no sufficient data to support the decision for amputation. Finally, the LEAP study did not recommend the use of injury severity scores as the determinant of limb salvage or amputation in the lower limb traumatic injuries as they lacked sensitivity.

Arterial injuries

The British Orthopaedic Association recommends that complex open fractures which are associated with vascular injuries should be treated according to the BOAST for arterial injuries. The Guideline Development Group reviewed one retrospective study which recommended that the temporary arterial shunt followed by orthopaedic stabilisation and definitive repair is the most appropriate option. However, the quality of the included study was shallow, mainly because of the poorly reported follow up and inaccurate data. The results need to be approached with caution, especially in the clinical setting as the lower revascularization rates in the arterial shunt group might have arisen from the small sample size.

Debridement

The available literature is supporting that the timing of debridement is a crucial factor that usually defines the final outcome. British Orthopaedic Association has advised that open fractures with signs of vascular compromise or compartment syndrome

need to be explored urgently, while high-energy and low-energy trauma require debridement within twelve and twenty-four hours, respectively. BOAST 4 guidelines were based on the findings of eighteen studies which were reviewed from the Guideline Development Group. Enninghorst and colleagues did not find any significant difference in the infection rates between early and late debridement [11]. However, the results of this study are questionable because there are no sufficient data for the deep infection rates and authors have not included reoperation rates and patients' functional outcome.

On the other hand, Malhotra, *et al.* showed that early debridement (<8hr) provides more favourable outcomes regarding the infection rates [12]. Although this study showed encouraging results, the significant differences between the sample sizes of the two groups create concerns for the validity of its evidence. Davis Sears, *et al.* supported that amputation rates are increasing significantly in patients who do not have their first debridement on the day of their admission [13]. Despite the large sample size of the study, the authors failed to record an appropriate classification, the degree of soft tissue injury and patient's factors.

Fernandes and colleagues agreed with the existing literature that overall there is no difference in the infection rates between early and late debridement [14]. However, they mentioned that the deep infection rates in Grade III fractures were higher in the group of late debridement (>6hr). Although the small sample size is a serious limitation of this study, BOAST guidelines could be modified in order to recommend early surgical treatment (<6hr) in high-grade injuries, providing that more randomised controlled trials will prove these evidence.

Internal fixation and soft tissue closure

British Orthopaedic Association recommends that surgeons should proceed with internal fixation of an open fracture only when it can be followed by soft tissue coverage. Three studies which were reviewed from the Guideline Development Group showed better results when immediate closure is following the internal stabilisation of the fracture compared to staged closure. However, these results should be reviewed with caution from the clinicians due to the poor quality of the included studies and the lack of data. Benson, *et al.* showed that open fractures could be closed primarily after appropriate surgical debridement with no effect in the deep infection rates [15]. Although these results are supported in the literature, this study had significant limitations. To be more specific, there was

no documentation of the type of fixation and no grading system was used by the authors. Also, six patients did not have appropriate follow up and this might have affected the study's results.

BOAST 4 guidelines support that soft tissue closure should be performed within 72 hours of the injury if surgeons are not able to close the wound primarily. Authors reviewed nine studies, which however were of low quality, that showed better results when the wound was closed primarily or in less than three days. D'Alleyrand, *et al.* conducted a study which showed that there is no difference in the risk of infection rates when the wound is being closed within the first seven days of the injury [16,17]. The sufficient amount of participants and the appropriate follow up period are the main strengths of this study. This practice might be appropriate to be implemented in the BOAST guidelines as will give the ability to surgeons to consider the closure of highly contaminated wounds within seven days from the injury. However, results should be treated with caution as this study was focused on tibia fractures and grading of the injuries was not reported.

Other

Documentation of the neurovascular status of the patient and early identification of compartment syndrome are clearly stated in the BOAST guidelines. Clinical observation and not continuous compartment pressure monitoring is supported by the randomised controlled trial by Harris, *et al.* which constituted the evidence for this recommendation. However, the low quality of the included studies and the generalizability of the results create concerns for its reliability. No evidence was found in the literature to show any advantages of the use of computerised tomography scan in the initial assessment of open fractures. The Guideline Development Group supported the implementation of the scanogram. Also, no relevant studies found to compare the efficiency of traction and vacuum splints.

Conclusion

Overall, BOAST guidelines include evidence-based recommendations for the management of open fractures. Controversial issues regarding antibiotic prophylaxis, soft tissue coverage and limb amputation should be investigated further in the literature so as to provide additional options for the clinicians in the management of these complex injuries.

Informed Consent Statement

Not required.

Conflict-of-Interest Statement

The authors declare that they have no conflict of interest.

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