Fluid Collections in Amputations Are Not Indicative or Predictive of Infection

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Abstract

Background In the acute postoperative period, fluid collections are common in lower extremity amputations. Whether these fluid collections increase the risk of infection is unknown. **Questions/purposes** The purposes of this study were to determine (1) the percentage of patients who develop postoperative fluid collections in posttraumatic

amputations and the natural course of the collection; (2) whether patients who develop these collections are at increased risk for infection; and to ask (3) are there objective clinical or radiologic signs that are associated with likelihood of infection when a fluid collection is present?

Methods We performed a review of all 300 patients injured in combat operations who sustained at least one major lower extremity amputation (at or proximal to the tibiotalar joint) and were treated definitively at our institution between March 2005 and April 2009. We segregated the groups based on whether cross-sectional imaging was performed less than 3 months (early group) after closure, greater than 3 months (late group) after closure, or not at all (control group, baseline frequency of infection). Our primary study cohort where those patients with a fluid collection in the first three months. The clinical course was reviewed and the primary outcome was a return to the operating room for irrigation and débridement with positive cultures. For those patients with cross-sectional imaging, we also collected objective clinical parameters within 24 hours of the scan (white blood cell count, maximum temperature, presence of bacteremia, tachycardia, oxygen desaturation), extremity examination (presence of erythema, warmth, and/or drainage), and characteristics of the fluid collections seen (size of the fluid collection,

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enhancement, complexity (simple versus loculated), surrounding edema, skin changes, tract formation, presence of air, and changes within the bone itself). The presence of a fluid collection on imaging was analyzed to determine whether it was associated with infection. We further analyzed clinical parameters, objective physical examination findings at the extremity, and characteristics of the fluid collection to determine if there were other parameters associated with infection.

Results Over half (55%) of the limbs demonstrated fluid collection in the early postoperative period and the prevalence decreased in the late group (11%; $p = 0.001$). There was no association between the presence of a fluid collection and infection. However, there was an association between objective clinical signs at the extremity (erythema and/or drainage) and infection ($p < 0.001$) in our primary study cohort.

Conclusions Fluid collections are common in combat-related amputations in the immediate postoperative period and become smaller and less frequent over time. In the absence of extremity erythema and wound drainage, imaging of a residual limb to evaluate for the presence of a fluid collection appears to be of little clinical use.

Level of Evidence Level III, diagnostic study. See the Guidelines for Authors for a complete description of levels of evidence.

Introduction

Combat-related amputations are often complicated by gross contamination, bacterial colonization, and frequent infections that necessitate open management with irrigation and débridement. Determining the optimal timing for closure of these residual limbs is therefore difficult [3, 5]. Given the large zones of injury and random pattern flaps often used for closure, potential spaces are created. Early closure results in an increased risk of infection that may subsequently result in a return to the operating room for débridement. By contrast, delayed closure can result in fibrotic and less pliable tissue, which can hinder efforts to perform an appropriate myodesis and myoplasty as well as adding patient morbidity through potentially unnecessary additional procedures. Experienced extremity surgeons learn to balance these risks; however, after closure of the amputation, the risk of postoperative infection remains high.

Postoperative fluid collections in amputations have previously been studied. In a study by Singh et al. [10], the

presence of a postoperative fluid collection in patients who had undergone amputations admitted to the rehabilitation ward was found to be 27% with most resolving within 30 days. Advanced cross-sectional imaging can be useful after amputations to evaluate symptomatic residual limb abnormalities such as painful neuromas [12]; however, any potential clinical benefit of identifying a postoperative fluid collection has not been defined, and the clinical implications of a fluid collection in the setting of an otherwise healthy-appearing residual limb are not known. In particular, whether these fluid collections increase the risk of infection is unknown, although fluid collections may be indicative of infection after procedures such as THA [1]. There is thus little guidance in the literature with regard to the management or clinical relevance of postamputation fluid collections.

The purpose of this study was to determine the frequency and clinical implications of postoperative fluid collections in combat-related amputations, in particular the possible relationship between fluid collections and postoperative wound infection. Specifically, we asked (1) how common are fluid collections are in the combat amputee, and do they resolve over time; (2) is the presence of a fluid collection associated with a higher likelihood of infection; and finally, (3) are there objective clinical or radiologic signs that are associated with likelihood of infection when a fluid collection is present?

Patients and Methods

After institutional review board approval, we retrospectively reviewed 300 consecutive major lower extremity amputations treated at our facility before April 2009. We included all patients injured in combat operations who sustained at least one major lower extremity amputation (at or proximal to the tibiotalar joint) and were treated definitively at our institution between March 2005 and April 2009. We excluded one patient as a result of an incomplete medical record.

We collected patient demographics, level of amputation, date of closure of amputation, and if cross-sectional imaging was performed for all patients. For all patients with cross-sectional imaging, we also collected clinical parameters within 24 hours of the scan (white blood cell count, maximum temperature, presence of bacteremia, tachycardia, oxygen desaturation), extremity examination (presence of erythema, warmth, and/or drainage), presence of a fluid collection on cross-sectional imaging, radiologic parameters of the fluid collection (size of the fluid collection, enhancement, complexity [simple versus loculated], surrounding edema, skin changes, tract formation, presence of air, and changes within the bone itself such as marrow

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edema, bone destruction, and periosteal reaction), and operative records after imaging. All of the records with advanced cross-sectional imaging were reviewed for the aforementioned objective signs (clinical parameters, extremity examination, and radiologic parameters) to determine if there were objective clinical and/or radiographic signs that were associated with infection. We defined an infection as a return to the operating room with positive deep cultures. All cross-sectional imaging was independently reviewed by a musculoskeletal fellowship-trained staff radiologist (MDM) who was blinded to clinical patient outcomes. A fluid collection was defined as a discrete collection of fluid seen on cross-sectional imaging that could be measured. The cross-sectional imaging modalities primarily consisted of CT scans; however, there were also two MRI scans and one ultrasound evaluation.

After initial definitive closure, the residual limbs were managed with the placement of a drain, with or without negative pressure wound therapy applied over the incision, followed by soft dressings of gauze, cotton cast padding, and a compressive elastic bandage in a figure-of-eight fashion to shrink the residual limb for eventual prosthesis wear. The dressing was removed on postoperative day 3 for the first wound check with removal of the drain(s) and negative pressure therapy. The residual limb was then redressed with an elastic compression dressing and gauze daily until the limb was deemed stable and less frequent wound checks were acceptable.

Patients were divided into three groups based on the timing of the cross-sectional imaging (Fig. 1). The “early” study group consisted of residual limbs in which imaging (CT, MRI) or ultrasound [US]) was performed less than 3 months after definitive closure. The “late” study group included limbs in which imaging was performed more than 3 months after definitive closure. Early cross-sectional imaging was obtained by other services when there was a change in the patient’s clinical course such as tachycardia, oxygen desaturation, or unexplained febrile episodes looking for a cause. Late cross-sectional imaging was obtained by the orthopaedic service for evaluation of residual limb pain or preoperative planning for revision of the residual limb such as heterotopic ossification excision. The control group included residual limbs that did not have cross-sectional imaging and served as a baseline for the frequency of infection. Our primary study cohort consisted of limbs in the early imaging cohort with a fluid collection.

A total of 74 patients who underwent amputations and underwent cross-sectional imaging (71 CTs, two MRIs, one US) were included in the study and 236 control subjects who did not undergo imaging. Of the 74 with cross-sectional imaging, 32 had a fluid collection identified. The average age of our patient population was 25 years (range, 19–46 years) with an average Injury Severity Score of 21

Fig. 1 Chart demonstrating the breakdown of our study population. Our control subjects were those without cross-sectional imaging. Our primary study cohort was those with a fluid collection at less than 3 months postoperatively.

(range, 9–57). The average time to scan was 20 days (range, 1–93 days) in the early imaging cohort, primary study cohort, and 336 days (range, 138–1464) in the late imaging cohort. The minimum followup was 8 months (average, 25 months; range, 8–57 months).

The decision to return to the operating room was made by the operative staff orthopaedic surgeon based on their clinical acumen if the residual limb was infected. If there was concern for infection as opposed to sterile wound dehiscence, intraoperative deep cultures were obtained with swabs and/or tissue samples.

Return to the operating room for surgical débridement with positive deep tissue cultures in solid growth media served as our primary outcome measure. If a patient with a residual limb returned to the operating room for repeat irrigation and débridement after initial definitive closure was closed, and after the second definitive closure was reimaged, that limb was counted again in our study as a separate extremity.

Statistical Analysis

Data analysis was performed using JMP 9 statistical software (SAS Institute Inc, Cary, NC, USA). A Pearson chi square analysis or Fisher’s exact test was used to determine potential differences in proportions between groups. For limbs that underwent cross-sectional imaging, the mean time from closure was compared with patients with and without fluid collections using the Mann–Whitney U-test. We defined statistical significance as a two-tailed α of < 0.05 .

Results

Fluid collections are more common in the acute postoperative period as compared with the late postoperative period

Fig. 2 Chart comparing our study cohort and control subjects with regard to our primary outcome of return to the operating room with positive cultures.

and reliably decrease with time. Thirty of the 55 (55%) patients in the early group had demonstrable fluid collections compared with two of 19 patients in the late study group ($p < 0.001$; odds ratio [OR], 10.2; 95% confidence interval [CI], 2.1–48.5; Fig. 1).

The presence of a fluid collection on cross-sectional imaging was not associated with infection in the residual limb. In our primary study cohort of early-scan residual limbs with a fluid collection, 31% (nine of 29) returned to the operating room and had a culture-positive wound infection compared with 25% (59 of 236) of our control subjects ($p = 0.483$; Fig. 2). One patient from the study group was excluded from analysis with regard to the presence of infection as a result of not having cultures taken intraoperatively when he returned to the operating room for superficial skin breakdown.

When determining if there were any clinical parameters that are associated with the likelihood of an infection when a fluid collection is present, only one clinical parameter was. Erythema and drainage were associated with return to the operating room and positive cultures ($p < 0.001$; OR, 106.8; 95% CI, 10.4–1094); however, with the numbers available, there was no association with the presence of other clinical concerns such as fever, leukocytosis, bacteremia, tachycardia, or oxygen desaturation without concurrent concern at the extremity. The only radiologic or imaging parameter significantly associated with the presence of infection was the presence of air ($p = 0.0272$, Fisher's exact test). Of the 74 patients who had cross-sectional imaging, nine had a clinical concern at the extremity to include erythema, warmth, or drainage (Fig. 3). Again, one patient with clinical concern was excluded in analysis as a result of lack of cultures when returning to the operating room. Of those eight remaining with an extremity concern, seven returned to the operating room and had positive cultures.

Fig. 3 Chart demonstrating the relevance of clinical signs of infection at the residual extremity as an indicator for infection.

Discussion

The ultimate goal of an amputation is to provide stable, robust distal coverage to produce a durable, painless residual limb. Ideally, the limb should tolerate early and intensive rehabilitation and prosthesis use. After closure, experienced surgeons maintain a high index of suspicion regarding the development of postoperative wound infections. Returning to the operating room for an infection delays rehabilitation, delays time to ambulation, and potentially results in loss of residual limb length or available soft tissue. Furthermore, unnecessary returns to the operating room without clear indications such as for an asymptomatic seroma that is likely to resolve with time can be detrimental without adding any discernable clinical benefit. Unfortunately, with the ease and availability of modern cross-sectional imaging, it is easy to cloud the clinical picture with incidental or distracting additional information [2], for example, in the setting of postoperative fever. Our study demonstrates that fluid collections are common in the acute postoperative period, decrease with time, and are not necessarily associated with an increased risk of infection. In the absence of a clinical concern at the extremity, looking for a fluid collection is of little clinical use.

Limitations of our study include its retrospective nature and the heterogeneity of our patient population. We did not explore the mechanism of injury nor other injuries sustained by our patients. We also had multiple orthopaedic surgeons involved in the care of these patients, and, although there is general consensus regarding the pre- and postclosure management principles for combat-related amputations, the decision to return to the operating room was left to the staff surgeon's discretion based on the overall clinical picture and their concern for the presence

of infection within the residual limb; however, this is reflective of the real-world management of trauma-related amputation complications rather than one surgeon's experience or protocol, and our results may therefore be more generalizable for it. Additionally, eight of the 12 patients from our study cohort returning to the operating room early had infection confirmed by positive cultures. The majority of our late imaging patients underwent CT for preoperative planning before heterotopic ossification (HO) excision, not screening for infection. This provided us a useful comparison population to document the shrinkage and/or resolution of fluid collections but may have spuriously elevated the true incidence of late fluid collections (11%) as a result of the propensity for bursa to develop over prominent areas of HO irritated by ambulation in a prosthetic socket. Another limitation is that not all fluid collections were explored; however, a deep space infection in a residual limb left untreated would not be expected to improve with time; instead, it would fester and result in a deteriorating clinical picture until appropriately managed. Finally, our control group did not undergo cross-sectional imaging. We do not doubt some of these residual limbs had fluid collections which were never imaged. However, we used this group simply to establish a baseline risk of infection within our amputee patient population for comparative purposes. Despite the ostensibly higher risk of infection in the study cohort who had proven fluid collections and, in most cases, underwent imaging to evaluate for infection, we did not detect a difference in infection rates between the two cohorts of primary interest.

The presence of a fluid collection after an amputation has been reported previously [6, 10, 11]. We found the proportion of patients with fluid collections in lower extremity amputations imaged within 3 months of definitive closure, with a median time from definitive closure to scan of 10 days, to be 55%. This decreased over time to 11% after 3 months. In a previous study by Singh et al. [10], the frequency of a fluid collection was 27%, which is approximately half what we observed; however, the initial imaging of their patients was performed later in the clinical course (after they were transferred to the rehabilitation ward) and was performed with US as opposed to CT. Singh et al. continued to follow the fluid collections with additional US every 2 to 3 days with 81% of the fluid collections undetectable by 30 days after closure and all of the fluid collections diminished and resolved by discharge. A followup study was subsequently performed by Singh and Venkateshwara [11], confirming that long-term outcomes of amputations such as wearing a prosthesis or the amount of time spent in a prosthesis were not affected by the presence of early fluid collections.

Infection after traumatic and combat-related amputation is relatively common with reported rates as high as 34%

[4, 9, 13, 14]. The frequency in our study cohort was similar at 31% and was not found to be different than control subjects without imaging. Given that this study demonstrated that the presence of a fluid collection is not associated with increased frequency of infection, we sought to determine if there were clinical or radiographic parameters of residual limbs with fluid collections that would be associated with increased frequency of infection.

The only clinical factor we found that was significantly associated with return to the operating room was a clinical concern at the extremity such as erythema, warmth, and wound drainage demonstrating that the results of, and indications for, advanced imaging should be used in conjunction with the surgeon's clinical examination to determine clinical relevance. Of note, excluding patients with a clinical concern at the extremity, patients with an early fluid collection had a rate of return to surgery of 23% (five of 22), which was no different from our control cohort. In the absence of concurrent clinical concern at the extremity, therefore, advanced imaging was of essentially no value. Conversely, if clinical concern at the extremity exists, the surgeon may elect to obtain advanced imaging if they believe that doing so may affect patient management, but they may also forego additional imaging in favor of operative exploration as clinically indicated. Thus, although cross-sectional imaging can provide useful information, it can also cloud the clinical picture and lead to unnecessary returns to the operating room (Fig. 4). In fact, incidental and otherwise asymptomatic findings, including fluid collections, are relatively common [8, 10]. Given the frequency of fluid collections in this population, we explored the association between specific parameters such as size, enhancement, complexity, and edema and infection (Fig. 5A–C). Our results were similar to those previously published by Malloy et al. [7]. Their study evaluated the association between CT finding and surgical drainage in pediatric neck abscesses. They found

Fig. 4 An axial CT scan of a patient with a hip disarticulation and the presence of a fluid collection. He returned to the operating room for irrigation and débridement with resultant negative cultures.

Fig. 5A–C Three patients with transfemoral amputations and deep rim-enhancing fluid collections (white arrows) with mild to moderate surrounding edema and skin thickening. **(A)** This patient returned to the operating room but had negative intraoperative deep cultures. **(B)** This patient returned to the operating room and had resultant positive intraoperative cultures. The final patient **(C)** healed uneventfully without any sequelae of the fluid collection and no further trips to the operating room.

that the appearance of the fluid collection on CT was not significantly associated with the need for surgical drainage, and those authors observed no association with rim enhancement or skin thickening. Likewise, they determined that the use of CT depends heavily on the surgeon's clinical suspicion of infection.

Our study demonstrates that fluid collections are common in combat-related amputees in the immediate postoperative

period and are seen less frequently in late scans, suggesting that they decrease in size and resolve with time. If discovered during an infection workup or incidentally, the presence of a fluid collection does not seem to indicate the presence of infection requiring surgical débridement in the absence of clinical signs of wound infection at the residual limb. Cross-sectional imaging performed to evaluate for infection in the absence of wound-specific concerns after definitive closure of major extremity amputations is therefore of questionable clinical use.

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