A retrospective analysis of the aspiration of fracture blisters

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ABSTRACT

Introduction: Fracture blisters are frequently encountered in orthopaedic trauma. Fracture blisters are associated with increased infection rates and wound breakdown. This study was performed to determine whether fluid aspirate from blisters is sterile or colonized.

Materials and methods: This is a retrospective review of a prospectively gathered cohort of patients. Patients with fracture blisters were recruited from a U.S. level I trauma center between 2011 and 2017. The blisters were aspirated under sterile conditions. Fluid was analyzed for gram stain and quantitative culture. Medical history obtained included blister location, presence of blood in blister, injury mechanism, gender, diabetes status and tobacco use. The demographic and behavioral descriptors were compared across positive aspirate or infection status using chi-square and Fisher's exact tests.

Results: We enrolled 64 patients in the study, seven of which had colonized aspirates (10.9%). None of the potential risk factors were significantly associated. Tobacco use trended towards significance for a positive aspirate ($p = 0.09$), but not for infection ($p = 0.61$). We followed patients for an average of 4.6 months. Four patients went on to have surgical site infections and none of them had positive aspirates.

Conclusion: Fracture blisters cannot be assumed to be sterile with more than 10% of our sample being colonized. Blister rupture during surgery or prepping for surgery could represent a contamination of the sterile field. No risk factors were significantly associated with colonization in our sample. However, colonized aspirates may not predispose patients to increased infection rates.

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1. Introduction

Fracture blisters are a common complication encountered by orthopaedic surgeons when treating fractures resulting from both high and low energy mechanisms. Varela et al. reported fracture blisters occur at an incidence of 2.9% of all fractures requiring hospitalization.¹ Anatomical areas with bony prominences due to little or no soft tissue coverage such as the elbow, knee, and ankle are more likely to develop fracture blisters.¹ There are two main types of fracture blisters, blood filled and serous filled. Blood filled blisters represent a more severe injury to the skin with complete separation of the dermoepidermal junction (DEJ) whereas serous

filled blisters exhibit only a partial separation of the DEJ.² Presence of these blisters frequently alter the proposed treatment or timing of surgery. The reason for change is the fear of wound breakdown or surgical site infection when incision is made through a blister bed.^{1–3} Several studies have shown that incisions made through blister beds, especially blood filled blisters, leads to increased risk for wound breakdown and infection.^{1–3} While there have been several studies investigating the best treatment of the blisters,^{1–3} very little investigation has focused on if blister contents are colonized with bacteria prior to rupture or if they are sterile.

The primary purpose of this investigation was to evaluate fracture blisters from patients seen in a level I trauma center and aspirate fluid under sterile conditions to send for analysis. Our hypothesis is that the fluid in the fracture blister is sterile. Secondly, we will investigate if colonization status of the fluid will influence infection rates following surgery.

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2. Materials and Methods

2.1. Patients

This investigation is an IRB approved, prospective study in which subjects were gathered from a single level I trauma center (from 2011 to 2017). Inclusion criteria were any individual with fracture blisters which have not yet ruptured and who are older than 18 years of age. Exclusion criteria included patients under the age of 18, persons who are terminally ill, prisoners, persons with cognitive impairments, pregnant women, or wards of the state.

Subjects with fracture blisters were identified from the emergency room, hospital floor, operating room and orthopaedic clinic. In all but a few cases, written informed consent was obtained prior to blister aspiration. If patients were not able to consent prior to aspiration, consent was obtained from the patient or power of attorney following aspiration. Medical history and social habits were also included, specifically presence of diabetes and tobacco use.

2.2. Blister characteristics

Each blister that was to be aspirated was prepared in sterile fashion using chlorhexidine or betadine and then aspirated with sterile needle. The aspirate was then sent to the laboratory for gram stain and quantitative culture. Other information regarding patient and blister was also collected including location of blister, mechanism of injury and quality of aspirate (bloody or serous). The blister was classified as blood filled or serous as per appearance of the blister. Blisters were then treated clinically, per standard of care, by unroofing the fracture blister and placing a dressing over the wound to promote healing and protect against infection from skin flora. This final step of unroofing blisters was done for all patients, regardless of study inclusion. The timing of surgery and use of antibiotics was left to the discretion of the treating surgeon.

2.3. Follow-up evaluation

Following aspiration and treatment of blisters, we continued to follow patients to determine if a positive blister aspirate influenced infection rates after operative intervention. Infection was defined as a need to return to the operating room for irrigation and debridement with or without hardware removal.

2.4. Statistical analysis

Possible predictors including tobacco use and diabetes were analyzed to determine if there was a correlation with bacterial colonization or developing an infection. Given the small cell sizes, we used the Fisher's exact test to determine whether distributions were significantly correlated. All analyses were performed using STATA (version 12.1).

3. Results

From 2011 to 2017, 64 blisters were aspirated, 57 were sterile and seven were colonized. This represents 10.9% (Table 1) of study subjects. With regard to character of the clinical appearance of the blisters, we encountered 29 blood filled blisters and 35 serous filled blisters. Sites where the blisters occurred included the following: leg (15) ankle (33), foot (13) and upper extremity.³ We enrolled 46 (72%) males and 18 (28%) females. Twenty-three patients used tobacco (35%) and eight (12.5%) were diabetic. Forty-one (64%) patients sustained a high energy injury and 23 (35%) were characterized as low energy.

Of the colonized blisters, four (57%) were blood filled and five

Table 1

Blister and Patient Characteristics Associated with Colonized vs. Sterile Status.

	Colonized (N = 7)		Sterile (N = 57)		p-value ^a
Bloody	4	(57%)	25	(44%)	0.69
Infection	0	(0%)	4	(7%)	1.00
Mechanism					1.00
High	5	(71%)	36	(63%)	
low	2	(29%)	21	(37%)	
Site					0.76
leg	2	(29%)	13	(23%)	
ankle	3	(43%)	30	(53%)	
foot	2	(29%)	11	(19%)	
upper extremity	0	(0%)	3	(5%)	
Gender					0.39
Male	4	(57%)	42	(74%)	
Female	3	(43%)	15	(26%)	
Tobacco	5	(71%)	18	(32%)	0.09
Diabetes	1	(14%)	7	(12%)	1.00

^a Fisher's exact test.

(71%) were high energy mechanism of injury. There were 4 (57%) males and 3 females with positive aspirates and one was diabetic in the colonized group. Sites of colonized blisters included leg (two), ankle (three), and foot (two). None of these characteristics were significant for predicting a positive aspirate. Five (71%) of the seven positive aspirates were tobacco users, but failed to achieve statistical significance. Out of our 64 subjects, there were four post-operative infections (Table 2) at a mean follow up of 4.6 months (range 0–13 months). None of the infections were in patients with a colonized aspirate.

4. Discussion

Fracture blisters represent a significant clinical obstacle for treatment of the underlying fracture. There is relatively little in the way of research regarding these blisters and their outcomes. The literature that is available indicates that these blisters carry an increased risk of wound break down and infection when incisions are made through the blister bed, especially in blood filled blisters.^{2,3} The aim of this study was to determine if this increased risk was due to bacterial colonization of the blister fluid.

The majority of the literature concerning fracture blisters is primarily focused on their treatment and wound complications, with extremely limited focus on the nature of the fluid contained therein. Varela¹ et al. published a study in 1993 describing the characteristics of fracture blisters associated with orthopedic

Table 2

Blister and patient characteristics across infection status.

	Infection (N = 4)		No Infection (N = 60)		p-value ^a
Bloody	2	(50%)	27	(45%)	1.00
Mechanism					0.13
High	1	(25%)	40	(67%)	
low	3	(75%)	20	(33%)	
Site					1.00
leg	1	(25%)	14	(23%)	
ankle	2	(50%)	31	(52%)	
foot	1	(25%)	12	(20%)	
upper extremity	0	(0%)	3	(5%)	
Gender					0.31
Male	2	(50%)	44	(73%)	
Female	2	(50%)	16	(27%)	
Tobacco	2	(50%)	21	(35%)	0.61
Diabetes	1	(25%)	6	(10%)	0.38

^a Fisher's exact test.

trauma. Fifty-three fracture blisters in 51 patients were identified in this study in characteristic locations of the body including the tibia, ankle, and elbow. Complications with wound healing and surgical incisions around fracture blisters were described with two major complications (post-operative wound infections) occurring secondary to fracture blisters being present in the operative field. Fifteen fracture blisters were biopsied and evaluated histologically showing evidence supporting the impression that fracture blisters are subepidermal vesicles. When ruptured, the blister bed quickly became colonized with skin pathogens, with colonization continuing until re-epithelialization was complete. The fluid within the intact blister was identified as a sterile transudate in six random blisters that were aspirated. This led to our hypothesis that fluid within fracture blisters is sterile.

In 2006 Strauss³ et al. described optimal treatment of fracture blister in a study evaluating the effectiveness of a particular treatment for fracture blisters in 47 patients. Each blister was unroofed and treated with Silvadene twice daily. The authors came to the conclusion that treatment of fracture blisters with the Silvadene regimen was successful in minimizing soft-tissue complications and by decreasing local bacterial counts in the blister bed. This led to faster re-epithelialization in all nondiabetic patients. This study also documents the complications of wound healing and infection that is common with fracture blisters, however they do not evaluate the fluid within the blister itself as a cause for infection.

Giordano et al.² performed a clinical study in 1994 where biopsies were obtained from the edges of thirteen fracture blisters. Two different subtypes of blisters were identified, blood-filled and clear-filled. The principle difference between the two is that the clear filled blisters still had some degree of epidermal cells which lead to faster re-epithelialization of the blister bed. This contributed to a decrease in morbidity associated with the blisters. The blood filled blisters had no remnant epithelial cells and so re-epithelialization was delayed and the associated morbidity was increased. While this study describes the histology of the blister bed it did not evaluate blister fluid for bacteria prior to rupture.

In 1995 Giordano et al.⁵ published a study that focused on the mechanics behind fracture blister formation. They came to the conclusion that the blisters were formed as a result of the separation of the dermal-epidermal junction, caused by the strain on the skin during fracture deformation. Separation occurs when a critical stress level is reached and the potential space fills with fluid as a result of the inflammatory cascade and change in starling forces.

Also in 1995, Giordano and Koval⁴ published an additional study of 53 cases of fracture blisters and the various methods of treatment for them. After about three months, 87% of the blister beds healed without incident. The cases that did not heal without complications were associated with blood filled blisters. Most of these required skin grafts to cover them. Based on these findings, the authors recommend leaving fracture blisters intact and only treating those that rupture spontaneously. Strauss published a study in 2006³ showing that a Silvadene dressing over the ruptured blister may be a better way to treat blisters decreasing healing time. Neither study evaluated if blood filled blisters are more likely to be infected prior to rupture when compared to serous filled blisters.

The strength of this study is that it provides clinically relevant

data from a cohort of patients at a U.S. Level I trauma center that challenges the idea that fracture blisters are sterile. Additionally, it is the largest study on record investigating fracture blister aspirate. The limitations include a relatively small sample size, though it is the largest collection studied in this manner, and the retrospective nature of the study. Also, factors such as closed versus open fracture blisters and the early or late appearance of blisters were not studied. Further investigation with a larger sample size is certainly warranted.

5. Conclusion

The results show that over 10% of the blisters aspirated were colonized with bacteria prior to rupture. These blisters should be treated appropriately prior to surgical intervention. If blisters are ruptured during surgery or preparation for surgery, this may represent a contamination of the sterile field. We were not able to identify predicting factors for a positive aspirate. Additionally, since none of the patients with positive aspirates went on to have an infection, we can report no evidence as to whether a positive aspirate increases the risk for infection.

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Credit author statement

Samuel Strebel: Conceptualization, Methodology, Investigation Data Curation, Writing — Original Draft. **Kimberly Burbank:** Writing — Review & Editing. **Jessica Tullar:** Formal Analysis. **Mark Jenkins:** Investigation, Project Administration. **Cyrus Caroom:** Project Administration, Supervision, Investigation, Writing — Original Draft, Methodology, Conceptualization.

Declaration of competing interest

None.

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Abbreviations

DEJ: dermoepidermal junction