

Real-time pH monitoring in a large animal model of the peri-prosthetic wound environment

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INTRODUCTION: During periprosthetic joint infections (PJI), the joint environment is assumed to be acidic, which has driven the development of various therapies and devices that respond to this presumed acidity. In our studies of the evolving post-operative environment, we have monitored wound/synovial fluid pH as a function of time after surgery. We previously validated that the postoperative pH of wound fluid was equivalent between sheep undergoing hip replacement (THR) and a large coxofemoral arthrotomy. Therefore, for this study, we limited our surgical intervention to a large coxofemoral arthrotomy using a standard surgical approach for THR in small ruminants. Herein, we report pH measurements of aseptic wound fluid in the immediate postoperative wound environment in a sheep arthrotomy model. We then compared our previously generated data sets of postoperative wound fluid pH obtained via Jackson-Pratt drains to pH measurements obtained in real-time within the wound environment using a remote pH capsule recorder (1). Our real-time pH monitoring data from this study are consistent with our previous findings, confirming that the postoperative wound fluid milieu is an alkaline environment.

METHODS: Under IACUC approval, a single hip of 4 female adult mixed-breed sheep was operated on and evaluated. Sheep underwent an index surgery to create a large defect in the coxofemoral joint via arthrotomy. An AlphaONE Wireless pH Capsule Reflux Monitoring System (LABORIE MEDICAL TECHNOLOGIES CORP.) and a JP drain were placed at the coxofemoral arthrotomy site for continuous pH monitoring and fluid collection (**Figure 2**). Samples were taken from the JP drain at wound closure (time 0), and every 6 hours for 96 hours, as fluid output allowed, and immediately analyzed for pH post-collection using a digitally calibrated pH meter. The Capsule Reflux Monitoring System began recording pH data at time 0 as well. Venous blood pH was also recorded at each time point using a point-of-care blood gas analyzer. At 96h, the JP drain was removed, and the pH capsule remained indwelling. No antibiotics were administered during this phase of this pilot study.

RESULTS: All four animals completed the study without major complications. All surgical wound sites were included in the analysis. Some J-P data points were missing due to insufficient production of wound fluid. The Capsule Reflux Monitoring System produced continuous pH readings for 96 hours. The starting pH, as measured by the AlphaOne monitor, ranged from pH 6.3 to pH 7.8. During the first 24 hours, the pH generally increased to a value of 7.7 or higher, where it remained for the duration of the 96-hour period. J-P drain pH values tended to be higher compared to those of the in-dwelling monitor but followed the same trend. Venous pH values remained at an average of pH 7.5 throughout the 96-hour period (**Figure 1**).

DISCUSSION: The published literature reports pH ranges between acidic and alkaline for the wound/synovial environments. In contrast, our studies show that the pH of the joint environment initially started at an alkaline pH and rose for the first 50 hours before leveling off at an average pH of 7.8. While values obtained in real time from the in-dwelling monitor were lower than those reported from J-P drain, the trend and alkaline status remained the same. These real-time in vivo pH data confirm our previous results, which indicate that the post-operative wound environment is rather alkaline than acidic. Venous pH values remained steady despite changes in both measurements of wound milieu (JP and indwelling capsule), confirming that variations in wound fluid values are not due to changes in the blood component of wound fluid. Future cohorts are needed to explore the pH of the postoperative wound fluid environment in real-time under septic conditions and during antimicrobial administration.

CLINICAL RELEVANCE: The postoperative woundfluid milieu differs from that of the native joint, which poses a unique set of environmental stressors to opportunistic pathogens, immune response, healing, and the local microenvironment. This invalidates the frequent assumption that the pH of the post-operative environment will mimic previous findings of acidic pH in synovial fluid. Furthermore, one reason that PJI is notoriously hard to treat could be due to the decreased effectiveness of antimicrobials in the alkaline local environment, suggesting that pH should be considered when developing a clinical diagnostic or treatment plan in arthroplasty. Overall, we do not yet fully understand the clinical implications pH has on host-microbial interaction or on PJI. Nevertheless, our findings may provide guidance for exploring mechanistic, diagnostic and therapeutic questions addressing PJI.

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ACKNOWLEDGEMENTS: Research was supported by NIAMS, NIH AR082038

IMAGES AND TABLES:

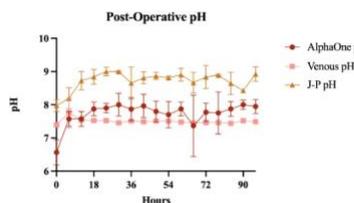


Figure 1 (above): pH as observed from 3 different samples in the immediate 96 hour post-operative period. Venous pH (pink) demonstrates that wound environment pH is independent of venous. Jackson-Pratt drain fluid pH (orange) measured by pH probe immediately following collection every 6 hours repeats results of previous studies in demonstrating an alkaline post-operative wound environment. AlphaOne pH (maroon) is slightly alkaline throughout the 96 hour test period, and follows the same pattern as J-P values, validating previous Jackson-Pratt study results

Figure 2 (below): AlphaOne pH capsule was implanted adjacent to total hip approach arthrotomy, and remained indwelling throughout 96 hour post-operative period. Real-time values were transmitted to a handheld reader via RF signal, and recorded at time of venous and drain collection for comparison.

