Pressure infusion comparison through the EZ-IO intraosseous needle using a Belmont FMS 2000 rapid infusion device and conventional pressure bag in the proximal humerus and proximal tibia of a swine (*Sus scrofa*) model

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Study objectives

To compare the infusion rates between the Belmont FMS 2000 rapid infusion device (RID) and pressure bag assisted flow through an intraosseous needle in the proximal tibia and proximal humerus using a swine *(Sus Scrofa)* model. Our secondary objectives were to determine at what pressure maximal flow rates occur, and to determine if infusions at these pressures cause bony damage or local vascular extravasation.

Methods

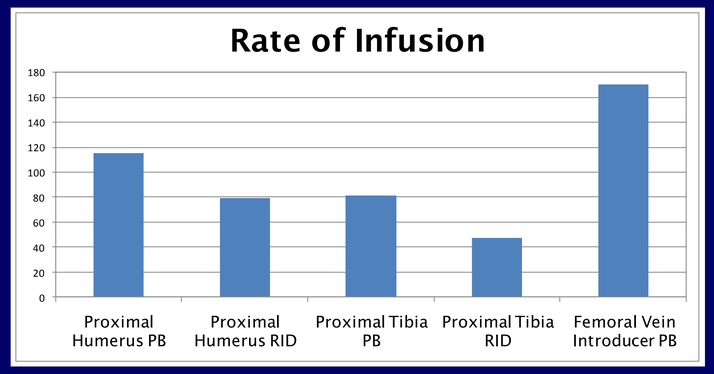
We completed a prospective interventional study comparing infusion flow rates between the RID and a conventional pressure bag through an EZIO needle. A 25mm EZIO needle was inserted into the proximal tibias bilaterally and a 45mm needle into the proximal humeri bilaterally of ten swine . Placement was confirmed by bone marrow aspiration, ease to flush saline and visualization under fluoroscopy. Each swine was randomized to use of either RID or pressure bag first; each animals served as its own control. For flow rate comparison, a femoral central venous 8.5 FR Introducer was placed. We performed the pressure bag infusion by inflating the cuff to a pressure of 600 mmHg. During the infusion, we inflated the pressure bag as necessary to maintain the highest achievable pressure. In the RID arms, the rate of infusion was overridden manually in an attempt to maintain a maximum pressure of 300 mmHg. Infusion pressure at the site was meassured with an Ashcroft General Purpose Digital Gauge at 10 sec intervals. We performed a 1 minute infusion of Optiray 320 at each site. Contrast extravasation was evaluated by fluoroscopy. Hystopathology was carried out to evaluate for damage. Statistical analysis of the infusion rates was performed using ANOVA and T-Test.

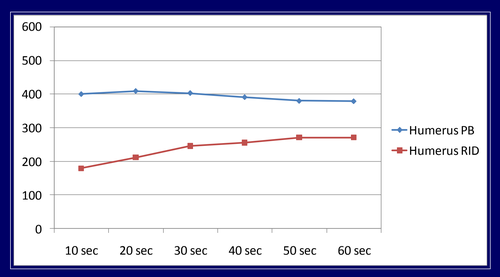
Results

The mean humerus infusion flow rate on the pressure bag (PB) arm was 115 mL/min and 79 mL/min in the RID arm ($p < 0.001$). The tibia infusion flow rate on the PB arm was 81 mL/min and 47 mL/min in the RID arm ($p < 0.002$).

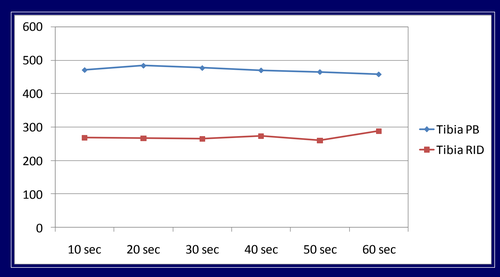
A comparison of IO flow rates

Site	Rate of infusion (mL/min)	Mean pressure (mmHg)
Proximal Humerus PB	115	394 (380 – 422)
Proximal Humerus RID	79	239 (180 – 278)
Proximal Tibia PB	81	471 (458 – 491)
Proximal Tibia RID	47	270 (260 – 288)
Femoral Vein Introducer PB	170	147 (133 – 155)

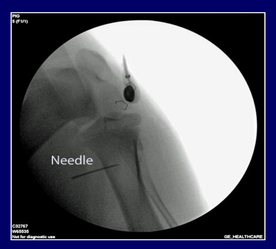


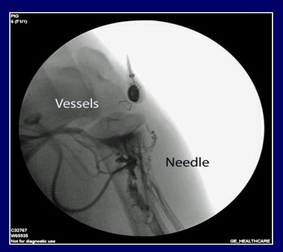


Comparison of mean proximal humeral intraosseous pressure



A comparison of mean proximal tibial intraosseous pressure





This study was presented as a plenary oral presentation at ATACCC 2009

Results - Continued

The infusion rate in the humerus was greater than the tibia with a $p < 0.014$ in the PB arms and a $p < 0.001$ in the RID arms. The mean infusion rate for the femoral 8.5 Fr introducer was 170 mL/min. ANOVA comparison of all four arms revealed significant difference in infusion rates between methods (<0.001).

We did not detect contrast extravasation during the humeral infusions. During the tibial infusions, extraosteal contrast extravasation of a small vessel was noted on one animal in the PB arm. This resulted in a small hematoma confirmed by pathology. Histopathology revealed minimal to mild subperiosteal and/or periosteal hemorrhage, with minimal to mild hemorrhage within the marrow space, and variable amounts of subperiosteal and scattered bone debris. These findings are consistent with intraosseous device placement and we considered them clinically insignificant.

Limitations

1. The use of an animal model.
2. The utilization of Optiray 320 contrast as the infusion solution.
4. The infusion period in this study was limited to one minute.
5. The preset pressure limitation built into the RID.
6. This study did not evaluate histopathology of the lung tissue for the potential risk of fat or bony emboli.
7. The data established in this study only pertains to the IO device, insertion sites, and RID used.

Conclusion

The infusion rate through the EZ-IO intraosseous needle was greater with PB system as compared to the RID. The higher rate may be related to the greater pressure generated by the PB system. Infusion through the humerus resulted in higher flow rates when compared to the tibia regardless of device. We found that the swine bone tolerated pressures > 300 mmHg without clinical histopathologic damage. Additional studies are needed to further evaluate high pressure (>300 mmHg) infusions using intraosseous devices.