

59th Medical Wing

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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



Maj Julio Lairet

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Investigators



- **J. R. Lairet** ¹

- **V. Bebarta** ¹

- **K. Lairet** ²

- **R. Kaprowicz** ¹

- **R. Johnson** ¹

- **B. Pitotti** ¹

- **J. Cowart** ³

- **S. Bolleter** ⁴

¹ Wilford Hall Medical Center,
Lackland AFB, TX

² United States Army Institute
of Surgical Research, Fort
Sam Houston, TX

³ 59th Clinical Research
Division, Lackland AFB, TX

⁴ AirLife of San Antonio,
San Antonio, TX

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Disclosure



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Background



- **Acute hemorrhage is the leading cause of battlefield deaths in modern warfare.**
- **Intravenous access is the cornerstone of resuscitation.**

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Purpose



- **Compare the infusion rates between the Belmont FMS 2000 rapid infusion device (RID) and pressure bag assisted flow through the EZ-IO® needle inserted into the proximal tibia and proximal humerus using a swine (*Sus Scrofa*) model.**



Purpose



- **Our secondary objectives:**
 - **To determine at what pressure maximal flow rates occur.**
 - **To determine if infusions at these pressures cause bony damage or local vascular extravasation.**

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Methods

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Methods



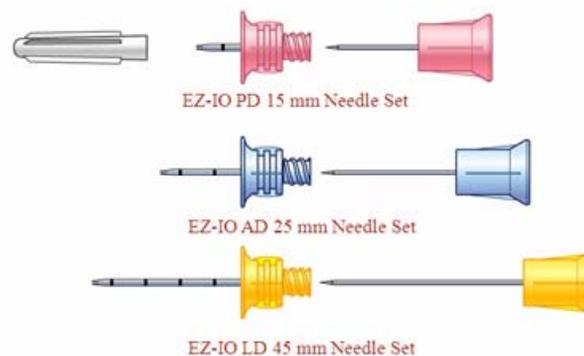
- **Prospective interventional study.**
- **Ten adult Yorkshire swine (*Sus Scrofa*).**



EZ-IO Placement



- **A 25mm EZ-IO needle into the proximal tibias bilaterally of ten swine and a 45mm needle into the proximal humeri bilaterally.**



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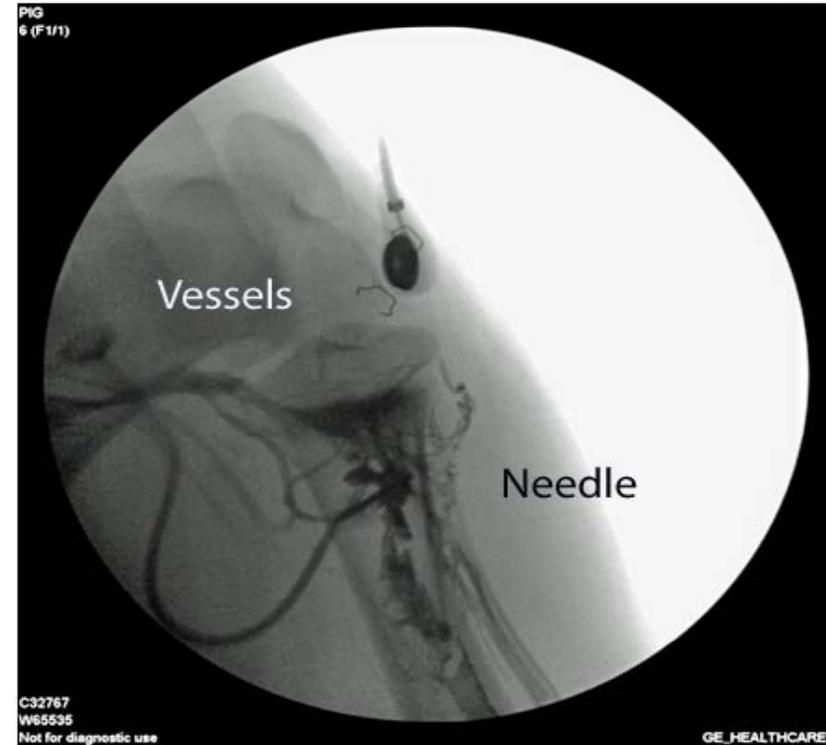
EZ-IO Placement



- **Placement confirmed by**
 - **Bone marrow aspiration**
 - **Ease to normal saline flush**
 - **Direct visualization by injection under fluoroscopy**



EZ-IO Placement



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Randomization



- **Each swine randomized to**
 - **RID first**
 - or**
 - **Pressure bag first**

 - **Each animal served as its own control**
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Flow rate comparison



- **For flow rate comparison, a femoral central venous 8.5 FR Introducer was placed via cutdown**





Infusion Rate



- **A bag of 250 cc of Optiray 320 was infused over 1 minute**



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Each infusion was observed under continuous fluoroscopy evaluating for extravasation of contrast.

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Pressure Bag Infusion



- **Cuff inflated to 600 mmHg**
- **Pressure was monitored**
- **Pressure bag was pumped as necessary to maintain the highest possible pressure**





Rapid Infusion Device



- **The rate of infusion was overridden manually in an attempt to maintain a maximum pressure of 300 mmHg**



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Pressure Measurement



- **Site infusion pressure measured with an Ashcroft General Purpose Digital Gauge at 10 sec intervals for 1 minute**



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RESULTS

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Results



- **The average weight of the subjects was 65.3 kg (range 59 to 79 Kg)**
- **Successful placement of the IO needle was confirmed in all the sites**



Comparison of flow rates

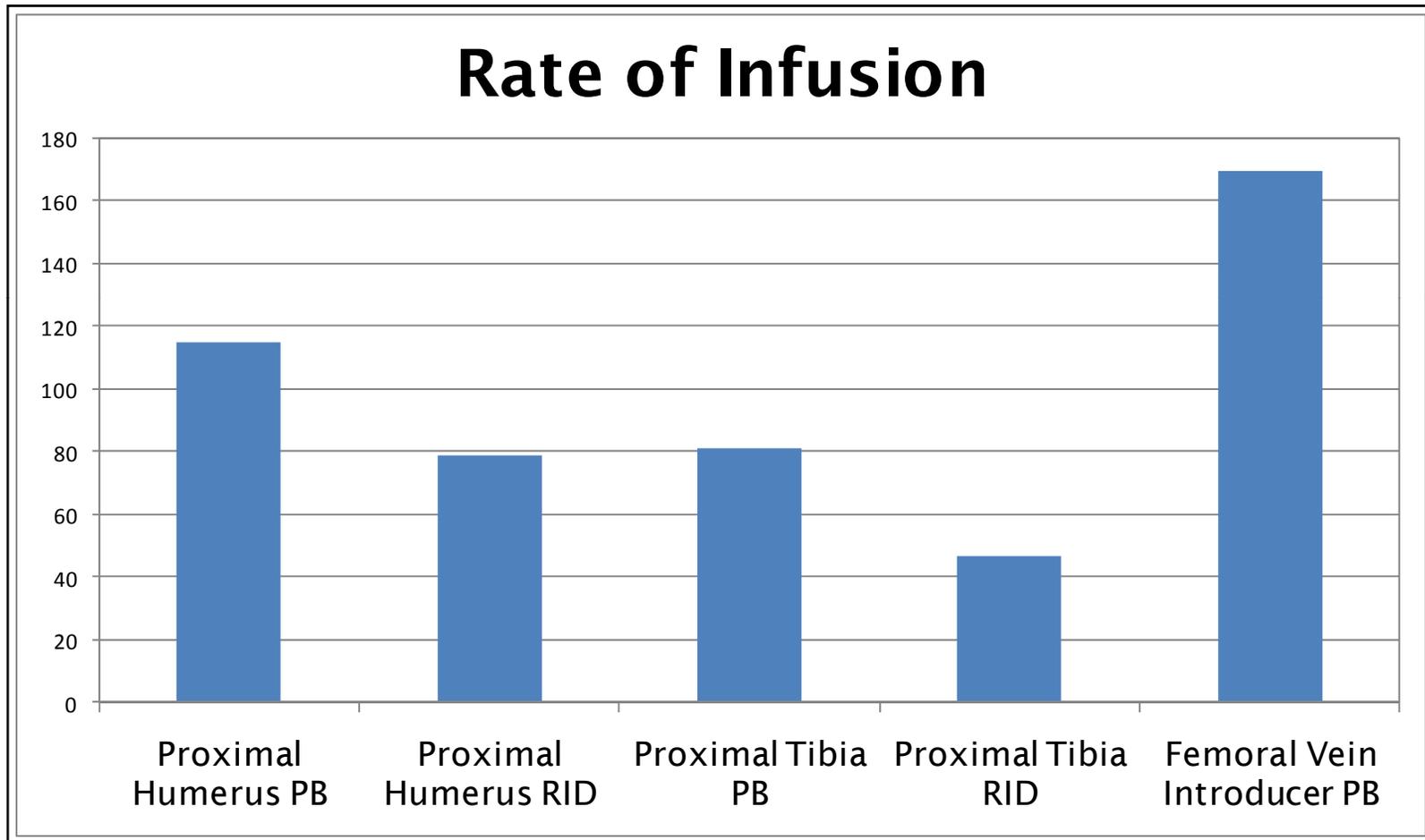


Site	Rate of infusion (mL/min)	Mean pressure (mmHg)
Proximal Humerus PB	115	394 (380 – 422)
Proximal Humerus RID	79	239 (180 – 278)
Proximal Tibia PB	81	471 (458 – 491)
Proximal Tibia RID	47	270 (260 – 288)
Femoral Vein Introducer PB	170	147 (133 – 155)

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Comparison of flow rates



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Humerus Mean Infusion Rate

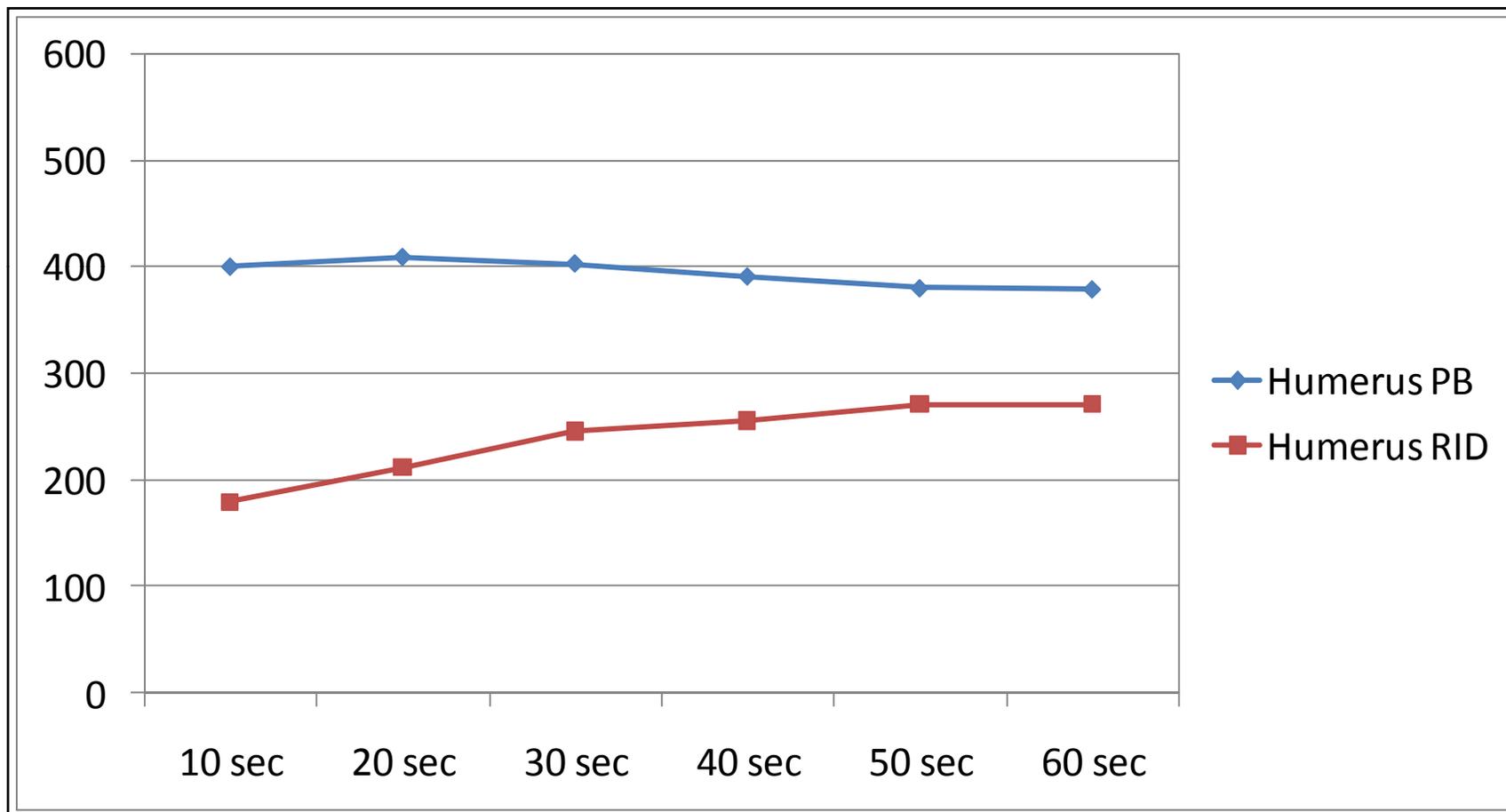


Site	Rate
Humerus – PB	115 mL/min (77-144 mL/min)
Humerus – RID	79 mL/min (66-114 mL/min)

$p < 0.001$



Comparison of mean proximal humeral IO pressure



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Tibia

Mean Infusion Rate



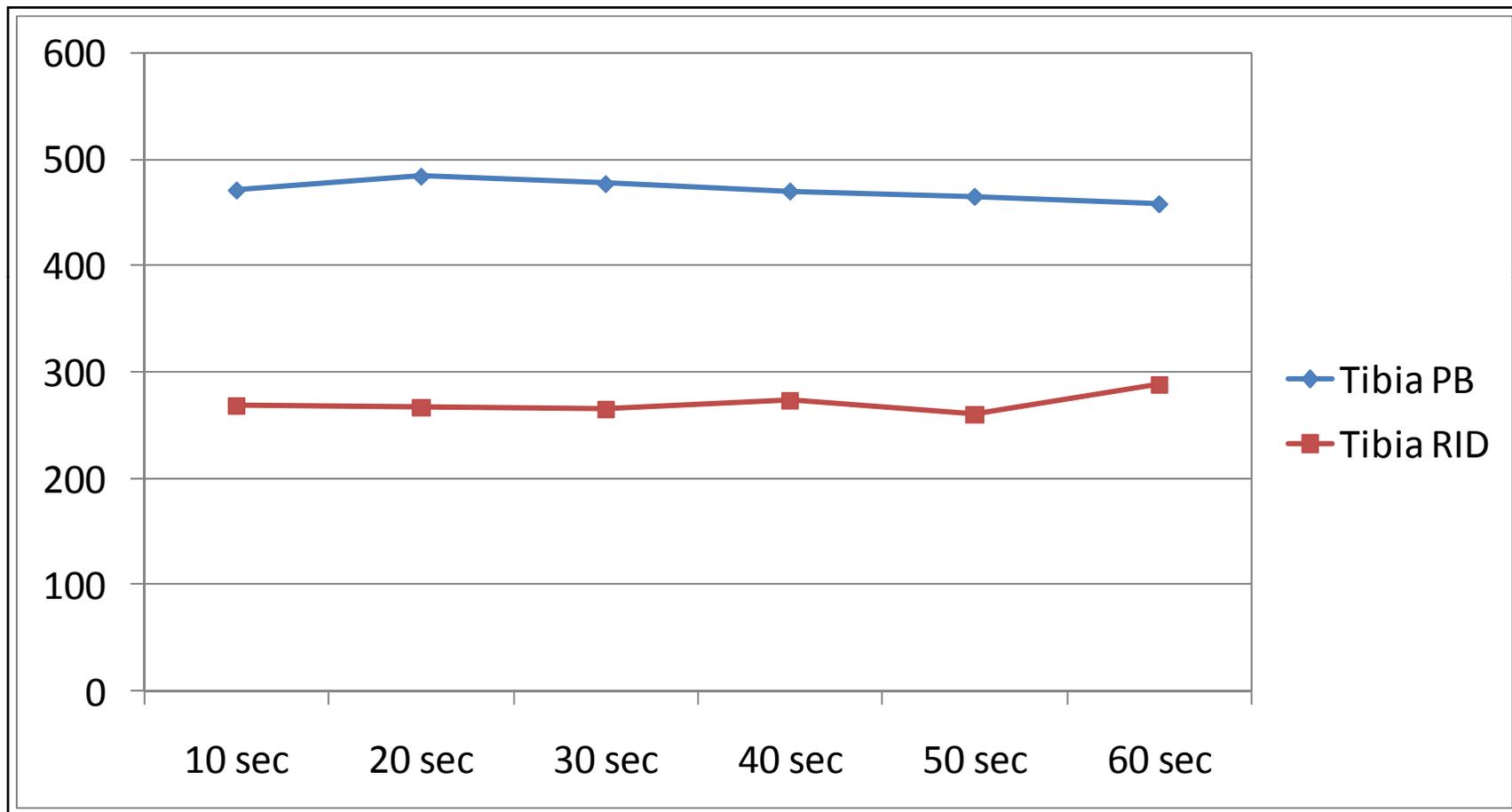
Site	Rate
Tibia – PB	81 mL/min (30-105 mL/min)
Tibia – RID	47 mL/min (36-58 mL/min)

$p < 0.002$

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Comparison of mean proximal tibial IO pressure



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Pressure Bag Arms Comparison



Site	Rate
Humerus – PB	115 mL/min (77-144 mL/min)
Tibia – PB	81 mL/min (30-105 mL/min)

$p < 0.014$



RID Arms Comparison



Site	Rate
Humerus – RID	79 mL/min (66-114 mL/min)
Tibia – RID	47 mL/min (36-58 mL/min)

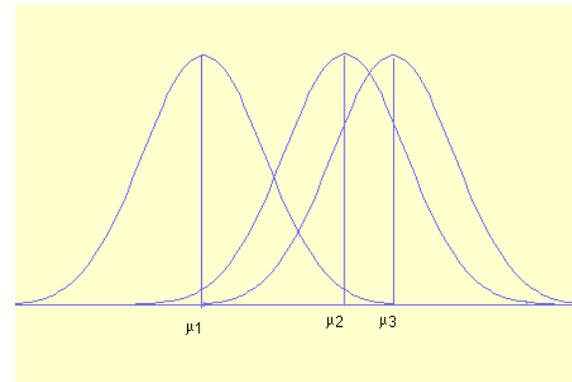
p<0.001



ANOVA



- **ANOVA comparison of all four arms revealed significant statistical difference ($p < 0.001$)**



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Extravasation of Contrast



- **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 pressure bag arm.**

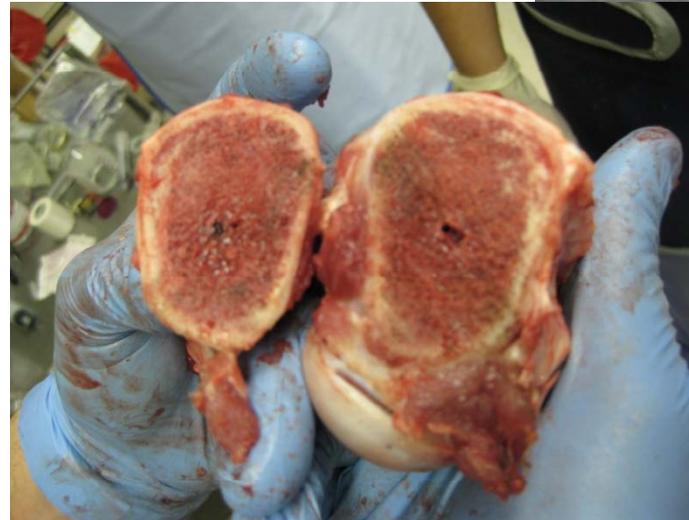
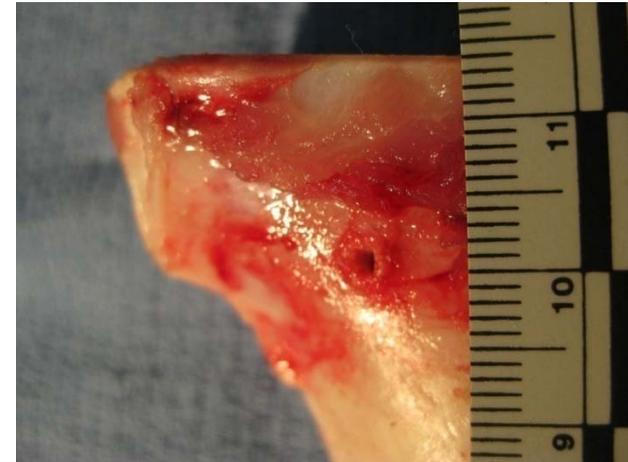


Histopathologic Examination



- **The IO device needle extended through the compact cortical bone on all samples and terminated within the medullary cavity or in cancellous bone.**
- **Fracture of the bone, misplacement, and posterior bone cortex disruption were not found.**

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Histopathologic Examination



- **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.**



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Limitations



- 1. The primary limitation is the use of an animal model.**
- 2. The utilization of Optiray 320 contrast as the infusion solution. The flow rates may not translate to crystalloids or blood products as the viscosity of contrast is different.**
- 3. The infusion period in this study was limited to one minute.**



Limitations



- 4. The preset pressure limitation built into the RID may have limited the actual flow rate achievable through the intraosseous device.**
 - 5. This study did not evaluate histopathology of the lung tissue for the potential risk of fat or bony emboli.**
 - 6. The data established in this study only pertain to the IO device, insertion sites, and RID used. This data may not translate to other IO devices, insertion sites, or RIDs.**
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Conclusion



- **the infusion rate was greater with pressure bag system as compared to the RID.**
- **The higher rate may be related to the greater pressure generated by the pressure bag system.**
- **Infusion through the humerus resulted in higher flow rates when compared to the tibia regardless of device.**



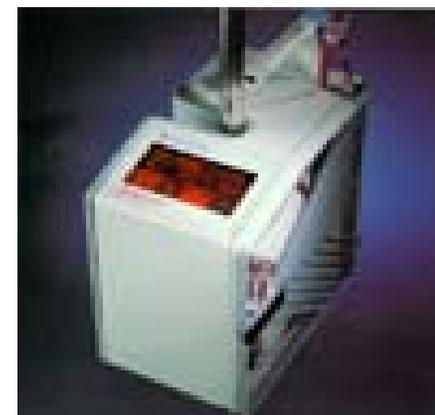
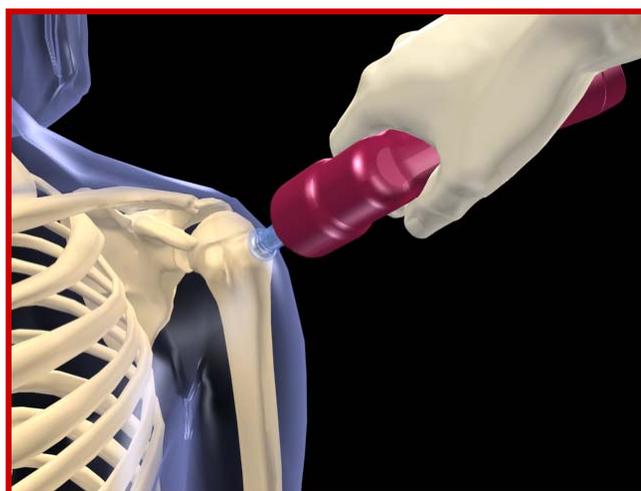
Conclusion



- **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.**



Questions?



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