

Annotated Reamer Irrigator Aspirator Abstracts

Prepared by members of the RIA Task Force. Last updated May 2017

The following selection of research papers can be found in this edition of *Injury*:

Giannoudis PV, Suk M, Pape HC (editors).

The Reamer Irrigator Aspirator (RIA) System: Applications and results of treatment. *Injury*. 2010 Nov; 41 Supp 2:i,S1–S98.

Giannoudis PV, Suk M, Pape HC. RIA: The journey just started but what's the future hold? *Injury*. 2010; 41 Supp 2:S1–S3.**Introduction to supplement**

In this introduction to the supplement on RIA, the editors note that the use of RIA has just started in the scientific community and they pose the question, “what does the future hold?”

Pfeifer R, Sellei R, Pape HC. The biology of intramedullary reaming. *Injury*. 2010; 41 Supp 2:S4–S8.**Annotated abstract**

This paper reviews the local biologic and physiologic effects of intramedullary reaming of long bones. The consequences for vascularity, pathophysiology of intramedullary pressure generation, and temperature increase are reviewed. **Techniques for avoiding local and systemic complications are summarized.**

Husebye EE, Lyberg T, Opdahl H, et al. Intravasation of bone marrow content. Can its magnitude and effects be modulated by low pressure reaming in a porcine model? *Injury*. 2010; 41 Supp 2:S9–S15.**Annotated abstract**

Investigators examined the impact of RIA with a traditional reaming system on the intramedullary pressure (IMP) and the intravasation of bone marrow contents in 28 young Norwegian landrace pigs that were exposed to femoral intramedullary reaming.

The investigators found a strong correlation between increased IMP and increased coagulation and cytokine responses. The number of emboli was not significantly correlated to IMP, but was strongly correlated to changes in the coagulation and cytokine responses. The investigators indicated that this study confirms the connection between increased IMP, increased coagulation activation, and the magnitude of pulmonary emboli in a model evaluating the effects of intramedullary reaming of intact pig femora. **Lowering of IMP during reaming, as obtained with RIA, reduced the magnitude of and the effects of bone marrow extravasation.**

Lovering AT, Elliott JE, Beasley KM, et al. Pulmonary pathways and mechanisms regulating transpulmonary shunting into the general circulation: An update. *Injury*. 2010; 41 Supp 2:S16–S23.**Annotated abstract**

This paper reviews the pathology of embolic insults following routine surgical procedures. **One pathway for emboli to bypass the pulmonary microcirculatory sieve is through an intracardiac shunt such as an atrial septal defect or patent foramen ovale. In the absence of intracardiac shunts, another pathway is an inducible large diameter intrapulmonary arteriovenous anastomoses.** These anastomoses are closed at rest but can open during hyperdynamic conditions such as exercise in more than 90% of healthy humans. The present evidence demonstrates the existence of inducible intrapulmonary arteriovenous anastomoses in healthy humans that are modulated by exercise, oxygen tension, and body positioning. The authors identify several clinical conditions associated with both arterial hypoxemia and an increased risk for embolic insults. They also suggest precautionary measures that should be taken during interventions to keep intrapulmonary arteriovenous anastomoses closed in order to prevent or reduce the incidence of paradoxical embolism.

Green J. History and development of suction-irrigation-reaming. *Injury*. 2010; 41 Supp 2:S24–S31.**Annotated abstract**

This paper reviews the development of a reamer system that integrates suction and irrigation into its design. In addition, reaming the intramedullary canal using this negative pressure system provides a unique source of biological material that is being increasingly investigated. **The author indicates that the cells and tissue harvested with this device have tremendous therapeutic promise.**

Klein C, Sprecher C, Rahn BA, et al. Unreamed or RIA reamed nailing: An experimental sheep study using comparative histological assessment of affected bone tissue in an acute fracture model. *Injury*. 2010; 41 Supp 2:S32–S37.

Annotated abstract

The investigators compared the results of RIA reamed nailing with conventional nonreamed nailing in a sheep acute tibia fracture model. Their study examined the displacement of the medullary content and its impact on cortical perfusion. Intravital staining with Procion red was used to study the effects on cortical perfusion.

After use of RIA, minute amounts of fat were observed in the cortex, whereas the endosteal third of the cortical bone was penetrated with fat after use of nonreamed nailing. Nonreamed nailing showed better perfusion in the endosteal tenth and periosteal third of the cortical bone, which was preserved to a lesser degree with use of RIA.

The investigators concluded that the RIA system significantly reduces fat intravasation, and thus the danger of system-wide damage.

Goplen G, Wilson JA, Mcaffrey M, et al. A cadaver model evaluating femoral intramedullary reaming: a comparison between new reamer design (Pressure Sentinel) and a novel suction/irrigation reamer (RIA). *Injury*. 2010; 41 Supp 2:S38–S42.

Annotated abstract

Investigators compared the Synthes Reamer/Irrigator/Aspirator (RIA) reamer and the Zimmer Pressure Sentinel reamer in 15 matched pairs of cadaveric human femurs. The force and speed of reaming was controlled. Two pressure transducers and two thermocouples were positioned into holes drilled in the femoral shaft to measure pressure and temperature. Femurs were reamed to a diameter 2 mm larger than the narrowest diameter of the intramedullary canal.

The investigators found that the maximum, minimum, and average intramedullary pressures during reaming were significantly lower with the Synthes RIA reamer than the Zimmer Pressure Sentinel reamer. There were no appreciable temperature changes observed during any of the trials. The investigators concluded that the Synthes RIA reaming system significantly reduces the intramedullary pressures produced during the reaming process compared to the Zimmer Pressure Sentinel reaming system.

Zalavras CG, Sirkin M. Treatment of long bone intramedullary infection using the RIA for removal of infected tissue: Indications, method and clinical results. *Injury*. 2010;41 Supp 2:S43–S47.

Annotated abstract

This paper reviews the use of RIA in the management of intramedullary infections of long bones. Several features of RIA appear to be beneficial for management of intramedullary infections. The RIA system permits reaming with simultaneous irrigation and aspiration, minimizing the residual amount of infected fluid and tissue in the medullary canal and decreasing the propagation of infected material. The disposable sharp reamer head combined with the continuous irrigation may avoid the increased temperature associated with standard reaming and its potential adverse effects on adjacent endosteal bone. **The authors conclude that the RIA device appears to be an effective and safe tool for debridement of the medullary canal and management of intramedullary infections of the long bones.**

Leddy LR. Rationale for reduced pressure reaming when stabilizing actual or impending pathological femoral fractures: a review of the literature. *Injury*. 2010; 41 Supp 2:S48–S50.

Annotated abstract

The paper reviews the literature regarding management of impending or actual pathologic fractures due to metastatic carcinoma. Reports have shown a high incidence of oxygen desaturation, hypotension, fat or air embolism, and mortality in treatment of femoral metastatic disease. The author discusses the benefits of IM nailing of femoral lesions and associated complications reported in the literature. The theoretical benefit of using the RIA system for reaming is reviewed. **The author concludes that reaming while irrigating under negative pressure provided through suction can potentially minimize cardiopulmonary and oncologic complications.**

Streubel PN, Desai P, Suk M. Comparison of RIA and conventional reamed nailing for treatment of femur shaft fractures. *Injury*. 2010; 41 Supp 2:S51–S56.

Annotated abstract

In this retrospective study of patients sustaining a femoral shaft fracture, investigators compared 66 patients treated with conventional reamed nailing with 90 patients treated with the reamer irrigator aspirator (RIA).

There were no significant differences between the two groups in length of hospital stay, length of ICU stay, or mechanical ventilation. Overall pulmonary complications occurred in 11% in the conventional reamer group and 16% in the RIA group ($p = 0.48$). There were no significant differences in delayed union or nonunion rates between the two groups. Overall healing complications were seen in 7% in the conventional reaming group and 14% in the RIA group ($p = 0.35$).

Investigators concluded that no statistical significance was reached with regard to pulmonary complications, healing rates, or death. They were unable to demonstrate favorable physiologic lung parameters with RIA use compared to conventional reaming.

Giannoudis PV, Tan HB, Perry S, et al. The systemic inflammatory response following femoral canal reaming using the reamer-irrigator-aspirator (RIA) device. *Injury*. 2010; 41 Supp 2:S57–S61.

Annotated abstract

The investigators evaluated the peripheral release of inflammatory mediators after femoral fracture and subsequent intramedullary reaming using the RIA device and conventional reamers. They found that IL-6 was elevated after trauma, and that reaming with RIA induced a measurable second hit response. Despite a higher ISS in the RIA group, the levels of IL-6 were similar to the levels measured in patients where femoral canal reaming was performed using conventional reamers. There was a low overall incidence of complications and similar between the two groups. **The authors concluded that large scale studies in polytrauma patients are desirable to further evaluate the immuno-inflammatory response using the RIA reamers prior to intramedullary nailing of the femur.**

Henrich D, Seebach C, Sterlepper E, et al. RIA reamings and hip aspirate: A comparative evaluation of osteoprogenitor and endothelial progenitor cells. *Injury*. 2010; 41 Supp 2:S62–S68.

Annotated abstract

The investigators studied the RIA aspirate from 26 patients undergoing intramedullary nailing of femur fractures and the iliac crest aspirates collected from 38 patients undergoing bone graft transplantation. Concentration of mesenchymal stem cells (MSC) and endothelial progenitor cells (EPC) were assessed by means of the MSC colony assay, EPC culture assay and flowcytometry (CD34, CD133, VEGF-R2), respectively. Osteogenic differentiation of MSC's was measured by von Kossa staining.

The RIA aspirates from the femur contained a significantly higher percentage of CD34+ progenitor cells, a significantly higher concentration of MSC and a significantly higher concentration of early EPC. The capability of MSC for calcium deposition was significantly enhanced in MSC obtained with RIA. The investigators reported that these results show that RIA aspirate is a rich source for different types of autologous progenitor cells that can be used to accelerate healing of bone and other musculoskeletal tissues.

Desai PP, Bell AJ, Suk M. Treatment of recalcitrant, multiply operated tibial nonunions with the RIA graft and rh-BMP2 using intramedullary nails. *Injury*. 2010; 41 Supp 2:S69–S71.

Annotated abstract

Investigators report on 9 cases of recalcitrant tibial nonunions treated using RIA graft, rh-BMP2, and intramedullary nail fixation. In two cases the Masquelet technique was used. All nonunions went on to successful healing at a mean of 27.6 weeks.

Stafford PR, Norris BL. Reamer-irrigator-aspirator bone graft and bi Masquelet technique for segmental bone defect nonunions: a review of 25 cases. *Injury*. 2010; 41 Supp 2:S72–S77.

Annotated abstract

Investigators retrospectively evaluated 27 cases of segmental bone loss treated with a standard Masquelet technique including RIA bone grafting. The segmental defect was located in the tibia in 19 cases and in the femur in 8 cases. The defect was due to an open fracture in 56% of cases, and due to infection or surgical debridement in 44% of cases. The average defect size was 5.8 cm (range 1–25 cm). Successful healing was obtained in 70% of cases at 6 months and in 90% of cases at 1 year postoperatively. There were no RIA related complications.

The investigators concluded that RIA bone graft appears safe and can yield predictable results for the treatment of very large segmental bone defects of the lower extremity, with 90% of nonunions healed at one year following a single bone graft procedure.

Cobbs KF. RIA use in a community orthopedic trauma practice: applying technology, respecting biology. *Injury*. 2010; 41 Supp 2:S78–S84.

Annotated abstract

This paper reviews ways in which the RIA device can be used, including acute fracture repair and bone graft harvest for treatment of established nonunions.

Silva JA, McCormick JJ, Reed MA, et al. Biomechanical effects of harvesting bone graft with the Reamer/Irrigator/Aspirator on the adult femur: a cadaver study. *Injury*. 2010; 41 Supp 2:S85–S89.

Annotated abstract

Investigators compared the biomechanical properties of 19 matched pairs of embalmed cadaveric femurs. One femur from each pair underwent reaming to 15 mm using RIA. Each femur was then loaded in torsion until fracture or to 113 Nm of torque. Mean torsional stiffness of the RIA reamed group was 532.1 Nm/rad (SD = 208.2), compared to 546.2 Nm/rad (SD=206) for the intact group. Seventeen of the RIA reamed specimens and all of the intact specimens withstood normal physiologic load seen with stair climbing (30Nm). Eccentric reaming of the distal anterior cortex occurred in the specimen in the RIA reamed group with the lowest torsional load capacity, highlighting the potential risk of eccentric reaming. Ten of the RIA reamed specimens fractured prior to reaching the testing limit, while 6 of the intact specimens fractured. **The investigators concluded that reaming the femoral cortex with the RIA device for the purpose of harvesting bone graft does not appear to dramatically diminish the bones mechanical properties or require postoperative weight bearing restrictions.**

Volgas DA, Burch T, Stannard JP, et al. Fat embolus in femur fractures: a comparison of two reaming systems. *Injury*. 2010; 41 Supp 2:S90–S93.

Annotated abstract

Investigators performed a prospective randomized trial of 20 patients with femur fractures treated with intramedullary nailing using either reamer-irrigator-aspirator or a conventional reamer. A four-chamber trans-esophageal echocardiogram was used to quantify the amount of fat presented to the right atrium. During the first pass of the reamer, the RIA showed a nearly-significant decrease in the volume of fat in the right atrium ($p=0.06$). During passage of the nail, there was a significant difference with the RIA group having less fat embolus than the conventional reamer group ($p=0.01$).

The investigators concluded that there was a statistically significant difference in the amount of fat presented to the lungs using a RIA versus conventional reamer.

Hartsock LA, Barfield WR, Kokko KP, et al. Randomized prospective clinical trial comparing reamer irrigator aspirator (RIA) to standard reaming (SR) in both minimally injured and multiply injured patients with closed femoral shaft fractures treated with reamed intramedullary nailing (IMN). *Injury*. 2010; 41 Supp 2:S94–S98.

Annotated abstract

The investigators performed a prospective, randomized, single-blind trial of patients with closed femoral shaft fractures randomized to undergo IMN with standard reaming or IMN with RIA. The patients were stratified by Injury Severity Score (ISS) and by presence or absence of chest injury with AIS > 3. Blood samples pre- and postoperatively were compared for the presence of IL-2, IL-6, IL-8, TNF, and IL-10 in plasma, and bronchioalveolar lavage samples were compared for IL-1b and IL-8 to determine the relationship between inflammatory markers and intramedullary reaming. Nine patients were randomized to the RIA group and 10 to the standard reaming group.

There was no statistically significant differences in the bronchial lavage samples between when RIA and standard reamers and when ISS >16 and <16 were compared, however, there were differences for the bronchial IL-8 change when those with chest injury were compared to those without chest injury. Investigators reported a trend towards higher levels for IL-6 in the standard reaming group at 24 hours postoperatively, while the IL-10 levels at the post-reaming time point were higher in the RIA group.

The investigators concluded that RIA may be protective of systemic inflammation, since in patients where RIA was used there were decreased levels of IL-8 in the bronchial washings and increased level of IL-10 in the serum.