THE EFFECT ON PULMONARY FUNCTION OF REAMED OR UNREAMED INTRAMEDULLARY NAILING FOR THE FEMUR IN SHEEP: UNDER NON-DAMAGED CONDITIONS

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Introduction: Pulmonary complication after intramedullary nailing has been focused on by many orthopedists. We investigated whether the pulmonary function and the coagulatory response after reamed or unreamed intramedullary nailing for the unfractured femur in normal lung status and non-hypovolemic condition of sheep was altered.

Materials and Methods: A total of 18 adult sheep, weighing 35-45kg, were used. The animals were treated in accordance with National Health and Research Council Ethics Committee Guidelines. Full approval was obtained from the Kitasato University Animal Ethics Committee. This experiment involved three groups (each, n=6) of sheep: reamed femoral nailing (RFN) groups, unreamed femoral nailing (UFN) group, and sham operation control (SOC) group. Femoral osteotomies, shock status, and post-traumatic wet lung conditions were not made throughout this experiment, in order to evaluate pure deleterious effects on pulmonary and systemic function induced by reamed or unreamed femoral nailing. The animals were ventilated using volume-controlled ventilation under halothane anesthesia with an FIO2 of 50% and a tidal volume of 15ml/kg with 5cmH2O of positive end-expiratory pressure.

Hemodynamic monitoring data including cardiac output (CO) and blood gas data were recorded, and also biochemical samplings (AT III, LPO, triglyceride, fibrinogen) via central vein were collected during reaming or insertion of the nails and 0 to 6 hours after nailing. Systemic vascular resistance (SVR), pulmonary vascular resistance (PVR), and A-aDO2 were calculated at each period on the basis of the above hemodynamic and blood gas data. Bronchoalveolar lavage fluid (BALF) in each animal was analyzed at 6 hours after nailing. The percentage of lavage cells containing neutrophil or brown-red fat droplets (lipid-laden cells) were calculated after examination of at least 200 cells on the slides stained with Sudan III. Myeloperoxidase (MPO) activity (U/g protein) in the pulmonary tissue was also examined after BAL. Both the BALF analysis and the MPO analysis were performed by the same technician without prior knowledge of RFN, UFN, and SOC group. All values are expressed as mean±SEM. All time-dependent parameters between three groups were analyzed using two-way repeated-measures ANOVA with post-hoc test. The cell counts in BALF and MPO activity data between the groups were analyzed using one-way ANOVA with post-hoc test. Statistical significance was defined as p<0.05.

Results: There were no significant differences in both the time courses of hemodynamic monitoring data excluding PAWP and those of blood gas data including PVR, SVR, and AaDO2 between three groups. The time courses of biochemical data among three groups showed no significance. In BALF analysis, the mean leukocyte cell counts (LCCs) of RFN, UFN, and SOC group were 18.6±1.7, 20.8±3.1, and 4.6±2.3, respectively. The mean LCCs of RFN and UFN groups were higher than that of SOC group (p<0.01). However, there was no significant difference between the mean LCC in RFN and those in UFN group. The mean lipid-laden cell counts of RFN, UFN, and SOC group were 31.2±10.6, 9.8±4.6, and 5.0±2.5, respectively. And the lipid-laden cell counts of RFN group was higher than those of UFN group and SOC groups (p<0.05). There was no significant difference between the mean lipid-laden cell counts in RFN group and those in UFN group. The mean MPO activities in pulmonary tissue of RFN, UFN, and SOC group were 404±30.4, 236.9±11.3, and 101.6±18.3, respectively. The MPO activity in pulmonary tissue of RFN group was the highest, when compared to those of the other two groups (p<0.01, Fig. 1).

Discussion: Several authors have reported pulmonary complications after intramedullary nailing (IMN) in clinical and experimental investigations. In our model we did not perform osteotomy of the femur before nailing. This might present a flaw for the clinical relevance of the data. However, sheep femurs are short compared with the body size of these animals. Thus intramedullary pressure changes comparable with those seen in humans are only expected if the femur is left intact. In addition, osteotomy can only be done in an open procedure. We therefore feel that it is appropriate not to perform osteotomy, pointed out by Pape et al. (1). Although some authors (1, 2) examined pulmonary dysfunctions after reamed IMN, they basically made impending fat embolism conditions by performing lymph-angiography fistula, and made unreamed IMN groups. On the other hand, all the investigations of pulmonary functions after RFN and UFN were performed under osteotomy conditions (3, 4). We thought that this experiment would be worthy of assessing pulmonary function and hyper-coagulatory response after RFN and UFN under non-fractured condition, normal lung condition, non-impending fat embolism status, and non-hypovolemic condition.

Conclusion: RFN in non-fractured condition, normal lung condition, non-impending fat embolism status, and non-hypovolemic condition did not influence on pulmonary function in physiological level, and did not induce hyper-coagulatory response, at acute stage. However, RFN could be detrimental to lung in subclinical level on the basis of both the BALF results and MPO assay results.

References

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Fig. 1 MPO activities in pulmonary tissue of various groups