

# **BONE CEMENT IMPLANTATION SYNDROME – EPIDEMIOLOGY, PATHOPHYSIOLOGY AND PREVENTION**

Akademisk avhandling

som för avläggande av medicine doktorsexamen vid Sahlgrenska akademien vid Göteborgs universitet kommer att offentligen försvaras i lokal R-aula, Sahlgrenska Universitetssjukhus, Mölndals sjukhus, Mölndal  
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av

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## **Avhandlingen baseras på följande delarbeten**

- I. Olsen F, Kotyra M, Houltz E, Ricksten S-E. Bone cement implantation syndrome in cemented hemiarthroplasty for femoral neck fracture: incidence, risk factors, and effect on outcome. *Br. J. Anaesth.* 2014; 113: 800-06.
- II. Kotyra M, Houltz E, Ricksten SE. Pulmonary haemodynamics and right ventricular function during cemented hemiarthroplasty for femoral neck fracture. *Acta Anaesthesiol. Scand.* 2010; 54: 1210-16
- III. Segerstad MHA, Olsen F, Patel A, Houltz E, Nellgard B, Ricksten SE. Pulmonary haemodynamics and right ventricular function in cemented vs uncemented total hip arthroplasty-A randomized trial. *Acta Anaesthesiol. Scand.* 2019; 63: 298-305
- IV. Segerstad MHA, Olsen F, Houltz E, Nellgard B, Ricksten SE. Inhaled prostacyclin for the prevention of increased pulmonary vascular resistance in cemented hip hemiarthroplasty - A randomised trial. Accepted. *Acta Anaesthesiol. Scand.* May 2019.



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## Abstract

Bone cementation implantation syndrome (BCIS) has significant morbidity and mortality for patients who are undergoing cemented hip hemiarthroplasty or arthroplasty. The aim of this thesis is to contribute with information of the epidemiological parameters of BCIS and identify risk factors. In addition, the pathophysiological ramifications of BCIS and possible interventions to prevent or reduce the risk of severe cardiopulmonary impairment due to BCIS are investigated.

A retrospective investigation of 1,016 patients who underwent cemented hip hemiarthroplasty due to displaced femoral neck fracture revealed a total incidence of BCIS of 28% (283/1,016 patients), regardless of the severity score. The peri-operative mortality rate was 2%, and 95% of the patients suffered from BCIS grade 3. According to the severity scores, the differences in mortality were not significant ( $p=0.15$ ) when comparing BCIS grade 0 with BCIS grade 1. However, the mortality rates for patients with BCIS grades 2 and 3 were significantly higher than for those with BCIS grade 0 ( $p<0.001$  and  $p<0.001$ , respectively) or grade 1 ( $p<0.009$  and  $p<0.001$ , respectively). An ASA-score  $>2$ , chronic obstructive pulmonary disease (COPD), the use of diuretics, and treatment with anti-coagulants (warfarin) were all independent risk factors for the development of BCIS. BCIS grade 2 or 3 was associated with a 16-fold increase in the 30-day post-operative mortality.

We observed a 45% increase in the pulmonary vascular resistance index (PVRI) for patients who were undergoing cemented hemiarthroplasty for femoral neck fracture, and this was accompanied by significant decreases in the right ventricle ejection fraction (RVEF), cardiac index (CI), and stroke volume index (SVI), with the reductions often being sustained throughout the surgical procedure. Gas exchange abnormalities were regularly observed in the forms of decreasing arterial  $pO_2$  and  $pO_2/FiO_2$  ratio and increasing  $V_D/V_T$  ratio. Therefore, cemented hemiarthroplasty in patients with femoral neck fracture results in pronounced pulmonary vasoconstriction and impairment of right ventricle (RV) function, accompanied by pulmonary ventilation/perfusion abnormalities.

Comparing cemented and un-cemented hip arthroplasty, the PVRI increased during and after prosthesis insertion by 45% and 20% in the cemented and un-cemented group, respectively ( $p<0.005$ ). The systolic and mean pulmonary arterial pressure (PAP) increased by 18% and 17% after prosthesis insertion in the cemented group, which was not seen in the un-cemented group ( $p<0.001$ ). There was a trend for a more pronounced fall in RVEF in the cemented group, while there were no differences in cardiac output or stroke volume between the groups. Therefore, the use of bone cement in total hip arthroplasty increases the pulmonary vascular resistance (PVR) and the after-load of the RV, with potentially negative effects on RV performance.

Comparing inhaled aerosolised prostacyclin with inhaled saline, the PVRI increased in both the saline (44%,  $p<0.001$ ) and prostacyclin (36%,  $p=0.019$ ) groups, with a less-pronounced increase in the prostacyclin group ( $p=0.031$ ). The RVEF decreased significantly in both groups, with no difference between the groups. Inhalation of prostacyclin attenuates the increase of PVR in patients who are undergoing cemented hip hemiarthroplasty and could attenuate/prevent the haemodynamic instability induced by the increase in right ventricular after-load seen in this procedure.

**Keywords:** bone cement implantation syndrome; femoral neck fracture; cemented hip hemiarthroplasty; pulmonary haemodynamic; right ventricle ejection fraction; pulmonary vascular resistance: hemiarthroplasty