Acute Pain and Analgesic Requirements After Pulmonary Endarterectomy With Deep Hypothermic Circulatory Arrest

Marc Giménez-Milà, MD, EDAIC,* Sebastian Videla, MD, PhD,† David Jenkins, BSc, MBBS, FRCS, MS,‡ Andrew A. Klein, MBBS, FRCA, FFICM,* Caroline Gerrard, BSc, MSc,* Jacinta Nalpon, BSc,* and Kamen Valchanov, BSc, MD, FRCA, FFICM*

Objectives: **To assess postoperative pain intensity and the analgesic requirements in the postoperative period in patients undergoing sternotomy for pulmonary endarterectomy involving deep hypothermic circulatory arrest.**

Design: **Retrospective cohort study.**

Setting: **Single-center hospital study.**

Participants: **Patients 18 years and older undergoing sternotomy for cardiac surgery between August 2012 and August 2014.**

Interventions: **No modification to usual clinical practice.**

Measurements and Main Results: **Intraoperative opioid and steroid administration, referral to the chronic pain unit, intensive care unit pain scores, and analgesic administration in the first 48 hours after the admission to the intensive care unit were recorded. Postoperative pain was evaluated by means of a categoric verbal scale from no pain (0) to severe pain (3); this is the routine analgesic scale used in the authors' intensive care unit. A total of 200 consecutive patients undergoing pulmonary endarterectomy (PEA group) were included in the study. No patient in the PEA group received morphine during surgery. The mean (standard deviation) postoperative pain intensity score at 24 hours was 0.30 (0.54) in the PEA group. Postoperative morphine was administered in 39% of patients. No PEA patient was referred to the chronic pain unit after hospital discharge.**

Conclusion: **The total analgesic requirements and pain score of patients undergoing sternotomy for pulmonary endarterectomy with deep hypothermic circulatory arrest seemed to be low.**

KEY WORDS: acute pain, analgesia, pulmonary endarterectomy, deep hypothermic circulatory arrest

OPTIMAL ACUTE POSTOPERATIVE pain control in cardiac surgery has been recognized as an important factor for reducing postoperative complications, including atelectasis, arrhythmias, and the development of chronic pain.[1-4] The literature regarding poststernotomy pain traditionally has been focused on the study of patients undergoing coronary artery bypass grafting or valvular surgery,[1,5,6] but few data have been published on patients undergoing more complex procedures such as pulmonary endarterectomy (PEA) with deep hypothermic circulatory arrest (DHCA).[7]

Severe pulmonary hypertension is a life-threatening condition. Early diagnosis and optimal treatment of this condition are advisable for decreasing complications, such as right ventricular dysfunction and ischemia.[8] Pulmonary hypertension in the general population has a prevalence of 2.6%,[9] with different possible etiologies.[10] Pulmonary hypertension could be a consequence of chronic thromboembolic pulmonary disease, classified as group-4 pulmonary hypertension (chronic thromboembolic pulmonary hypertension [CTEPH]). In CTEPH patients the longstanding thrombotic obstruction of the pulmonary artery vasculature leads to symptoms and hemodynamic disturbances.[11]

PEA is the treatment of choice for CTEPH; it is offered to patients depending on the location of the disease, severity of hemodynamic and ventilatory impairment, symptomatology, and comorbidities.[12-14] PEA is a complex surgical procedure, in which profound physiologic disturbances are required—DHCA and administration of high-dose steroids—to obtain a bloodless view of the pulmonary artery lumen and therefore allow a successful endarterectomy.[15]

The aim of this retrospective study was to assess the analgesic requirements of patients undergoing PEA surgery involving DHCA. To the authors' knowledge, this was the first study, based on a large cohort, to provide data on perioperative pain management of patients undergoing PEA.

METHODS

Study Design

This study was a single-center, retrospective analysis from a prospectively compiled database of a cohort of patients undergoing PEA with DHCA. The project received approval from the Research Ethical Committee of Papworth Hospital, Cambridge, United Kingdom, and the need for written informed consent was waived. The study was performed according to the stipulations of the Declaration of Helsinki and the level of protection of confidentiality concerning the protection of personal data as required.

Study Population

The inclusion criterion was: patients undergoing PEA with DHCA who were $\geq$18 years old. Exclusion criteria were previous chronic pain diagnosis, $\geq$24 hours of postoperative mechanical ventilation of the lungs, combined procedures, and intraoperative use of remifentanil.

The data collected were sex, intraoperative opioid administration, steroid administration, mechanical ventilation time, referral to the chronic pain unit, intensive care unit (ICU) pain

*From the *Department of Anaesthesia and Intensive Care, Papworth Hospital, Cambridge, United Kingdom; †Department of Experimental and Health Sciences, Universitat Pompeu Fabra, Barcelona, Catalonia, Spain; and ‡Department of Cardiothoracic Surgery, Papworth Hospital, Cambridge, United Kingdom.*

Address reprint requests to Marc Giménez-Milà, MD, EDAIC, Department of Anaesthesia and Intensive Care, Papworth Hospital, Cambridge CB23 3RE, United Kingdom. E-mail: marc.gimenez@nhs.net

1053-0770/2601-0001$36.00/0

http://dx.doi.org/10.1053/j.jvca.2015.11.013

scores, and analgesic drug administration in the first 48 hours after admission to the ICU.

Anesthetic and Surgical Procedures

According to the authors' local protocol, induction of general anesthesia was with midazolam, 0.1 mg/kg, a propofol bolus of 20 to 50 mg, fentanyl, 10 to 20 μg/kg, and pancuronium for muscle relaxation. Maintenance of anesthesia was with propofol infusion, 4 to 6 mg/kg/h, and patients also were administered a tranexamic acid bolus of 1 g and a continuous infusion at 5 mg/kg/h. All patients received 1 g of methylprednisolone.

The hemodynamics of all patients were monitored using arterial, central venous, and pulmonary artery catheters and a cerebral oximetry monitor, INVOS (Medtronic, Minneapolis, MN). The cerebral oximetry monitor provided useful information for cerebral oxygenation in critical moments of the procedure, such as during DHCA and the patient coming off cardiopulmonary bypass.

All PEA patients underwent sternotomy and systemic heparinization that were followed by cardiopulmonary bypass after aortic and venous cannulation. Hypothermia was achieved with extracorporeal circulation, with a goal temperature of less than 20°C. At this temperature, DHCA was used to facilitate surgical dissection. Once the dissection was completed, mechanical ventilation was started (fraction of inspired oxygen [F_IO_2] 0.21, tidal volume 5 mL/kg, rate 10, positive end-expiratory pressure 6 cm H_2O) and the body was progressively rewarmed to 37ºC. Thereafter, oxygen concentration was increased to F_IO_2 0.6, spontaneous circulation was resumed, the patient was weaned from cardiopulmonary bypass, and the chest was closed. The patient was transferred to the ICU intubated and under mechanical ventilation.

Perioperative Analgesia Management

In all patients, the intraoperative analgesia consisted of 1,000 μg of fentanyl, and hypnosis was achieved with a propofol infusion of 4 to 6 mg/kg/h.

After extubation, patients received analgesia tailored to their analgesic requirements. Acetaminophen was the first-line analgesic and administered routinely for the first 48 hours. The second-line analgesic was dihydrocodeine or tramadol, and the third-line analgesic was morphine infusion or oral morphine.

Intensive Care Management

In the early postoperative period all patients underwent sedation with propofol infusion at 2 mg/kg/h. As part of the standard postoperative protocol, patients received mannitol, 12.5 g every 6 hours, and diuretic therapy with furosemide, both strategies performed with the objective of reducing pulmonary edema. Once hemodynamic and respiratory stability were achieved, the protocol of weaning the patient from mechanical ventilation was started.

The oxygen concentration was reduced progressively—every 2 hours—by decreasing F_IO_2 to 0.40, aiming for a systemic pO_2 above 12 kPa. Once this was achieved, positive end-expiratory pressure was decreased at a rate of 1 cm H_2O every hour to a minimum of 2 cm H_2O. Sedation then was stopped, enabling a neurologic assessment to proceed with extubation.

Postoperative Pain Assessment

Pain scores were recorded by nursing staff. The postoperative pain was recorded in a categoric 4-level verbal scale, from the absence of pain (0) to mild pain (1), moderate pain (2) or severe pain (3). The pain score was assessed at 3 postoperative times in the PTE group at 24 hours, 36 hours, and 48 hours.

Chronic Pain Unit Referral

Data regarding the need for specialized chronic pain analgesic treatment were collected from patient discharge to August 2015. After discharge all PEA patients were followed up by a specialist nurse who interviewed the patients via telephone at the following postoperative times: between 1 to 2 weeks and between 3 to 4 months after hospital discharge. In the first year after surgery all patients were seen in the pulmonary hypertension clinic by a surgeon. Patients with persistent postoperative pain were referred to the chronic pain unit of the same center where the surgery had been performed.

Statistical Analysis

Because of the exploratory and descriptive character of this retrospective study, no formal sample size estimation was performed. The sample size of the PTE group was defined as all patients who underwent surgery during the inclusion period between August 2012 and August 2014.

A descriptive analysis was performed for baseline population characteristics. Continuous variables were described as mean (standard deviation [SD]), and categoric data were summarized as absolute frequency and percentages.

RESULTS

Patient Characteristics

All consecutive patients who underwent surgery in the cardiovascular surgery department who fulfilled the inclusion criteria were identified and included in the analysis. The study included 200 PEA patients (109 men and 91 women). The baseline characteristics of the patients included in the study are presented in Table 1. The mean (SD) mechanical ventilation time for PEA patients was 1,159 (655) minutes.

Table 1. Baseline Characteristics of All Patients With Pulmonary Endarterectomy (n = 200)

	PEA
Age (y)	
Mean (SD)	56.8 (15.3)
Sex	
Male (n, [%])/female (n, [%])	109 (54.5%)/91 (45.5%)
Intraoperative	
Methylprednisolone (yes)	200 (100%)

Abbreviations: PEA, pulmonary endarterectomy; SD, standard deviation.