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Impact of different sedation protocols and perioperative procedures on patients admitted to the intensive care unit after maxillofacial tumor surgery of the lower jaw: A retrospective study

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ABSTRACT

Maxillofacial tumor surgery often necessitates prolonged invasive ventilation to prevent blockage of the respiratory tract. To tolerate ventilation, continuously administered sedatives are recommended. Half-time of sedative or analgesic medication is an important characteristic by which narcotic drugs are chosen, due to the fact that weaning period increases with half-time. The aim of our study was to investigate whether a change in sedation regimen would affect the length of invasive ventilation or intensive care unit stay and medical costs. Additionally, the impact of various surgical procedures was analyzed. Data of 157 patients after mandibular surgery were retrospectively analyzed over 5 years in count regression models. Of those patients, 84 received a sedation regimen with sufentanil and midazolam and 73 with remifentanil and propofol. The impact of the surgical procedures (tracheostomy, tumor resection, neck dissection and length of operation) and the patient age and sex were analyzed with respect to length of ventilation and ICU days. Cost savings were calculated. Our data show that patients receiving remifentanil/propofol had fewer ventilation days (2.5 ± 2.5 versus 6.1 ± 4.6 days, $P < 0.001$) and were discharged earlier from the intensive care unit than patients receiving sufentanil/midazolam (5.1 ± 3.8 versus 9.2 ± 6.2 days, $P < 0.001$), leading to calculated cost savings of about 8000 Euro per patient. Length of operation negatively influenced length of ICU stay ($P < 0.001$). In conclusion, short-acting drugs such as remifentanil/propofol, as well as tracheostoma and shortened surgery duration may reduce the postoperative need for invasive ventilation and length of intensive care unit stay.

1. Introduction

Maxillofacial tumor surgery often necessitates prolonged invasive ventilation. On one hand, blockage of the respiratory tract due to swelling in the oral cavity and neck is prevented through intubation. On the other hand, healing of the anastomosis is to be supported by immobilization, especially in cases of short veins of small diameter that might be stretched and thereby collapse or prevent any kinking of the microvascular pedicle.

To tolerate invasive ventilation and to reduce pain, anxiety, and agitation, intensive care patients receive a sedative and an analgesic administered via an infusion pump (Patel and Kress, 2011; Roberts et al., 2012). Since adequate pain control can reduce the amount of needed sedatives, an analgesia–sedation regimen should be always used (Patel and Kress, 2011), resulting in a decrease in weaning time and a shorter length of intensive care unit (ICU) stay (Rozendaal et al., 2009).

Opioids are the most important group of analgesics to ensure adequate pain control in intensive care patients (Patel and Kress, 2011; McGrane and Pandharipande, 2012). Regularly used opioids

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include morphine, hydromorphone, sufentanil, fentanyl, and remifentanil (McGrane and Pandharipande, 2012). To induce sufficient sedation, propofol, benzodiazepines or the α_2 agonist dexmedetomidine may be continuously administered (McGrane and Pandharipande, 2012). Those available analgesic and hypnotic substances have different pharmacologic characteristics. The ideal sedative drug should be inexpensive, cause analgesia or sedation within a short period, and hardly affect other physiologic parameters. In fact, the half-time of sedative or analgesic medication might increase if continuously administered, leading to prolonged elimination (McGrane and Pandharipande, 2012). This in turn results in a prolonged weaning period, also enhancing the risk of reintubation and an extended overall duration of ICU stay. The prolonged ICU stay in turn triggers the occurrence of infections or thromboembolic events, seriously adding to the mortality of intensive care patients. Beside those considerations, prolonged sedation can further mask clinical symptoms and therefore hamper important diagnoses such as cerebral insult (Costa et al., 2006). The conflict of surgically desirable “no movement” policy and currently used cooperative sedation regimens and their impact on medical costs is therefore apparent.

The aim of our study was to evaluate the effect of two sedation protocols and several surgical procedures on the duration of mechanical ventilation and overall length of ICU stay and thereby on the clinical costs.

2. Material and methods

2.1. Patients

The study was carried out in accordance with local legal requirements and the Declaration of Helsinki (1975) and was approved by the institutional ethics committee. Inclusion criteria were age over 18 years and dependence on invasive ventilation and sedation after elective maxillofacial tumor surgery. The data of all patients fulfilling the inclusion criteria admitted to our ICU were retrospectively analyzed for the years 2007–2012. Patients had oral squamous cell carcinoma, ameloblastoma, or metastasis of distant carcinomas manifesting in the lower third of the face and underwent mandibular surgery. Tumor resection with bilateral neck dissection followed by reconstruction with microvascular transplants may lead to considerable constriction of the airway. In these patients, tracheostomy was performed to ensure a safe airway. Patients with smaller tumors, unilateral neck dissection, or cutaneous flaps such as a thin radial forearm flap did not require tracheostomy.

Between January 2007 and February 2010, invasively ventilated ICU patients received a sedation regimen consisting of midazolam and sufentanil. Afterward, the sedation regimen was adapted and changed to propofol and remifentanil.

Postoperative sedation was prolonged to allow for ventilation up to the point when the following criteria permitted weaning and extubation: hemodynamic stability, defined as no need for vasoactive medication, sufficient gas exchange by spontaneous ventilation, partial pressure of carbon dioxide adjusted to keep blood pH in the normal range, normal body temperature, and airway not constricted due to swelling of the tongue, neck, or flap.

2.2. Analyzed parameters and cost calculations

Analyzed parameters were the patients' age, sex, and Simplified Acute Physiology Score (SAPS II), the sedation regimen used, as well as surgical procedures, namely, tracheostoma, tumor resection, neck dissection, and microvascular reconstruction. For all patients fulfilling the inclusion criteria, data could be extracted from the electronic case documentation systems used by our anesthesiology department and ICU. The SAPS II represents the severity of disease for patients at ICU admission and gives the predicted mortality (Le Gall et al., 1993). It includes the patient's demographic data and preexisting chronic diseases as well as physiologic, laboratory, and ventilator-associated parameters. The SAPS II describes the morbidity of a patient or a group of patients compared the outcomes of others.

Patient characteristics are summarized in Table 1.

Overall costs per patient and ICU days were provided by the finance department for every analyzed year. Those costs are the mean calculated charges per patient and ICU days independent of care requirements or respiratory status. To offset sedation costs, charges for sedatives and opioids were calculated for all ventilation days within a sedation regimen group by using mean sedative infusion rate for a patient with an average body weight of 70 kg. Ventilated patients needing sedation were defined as patients aided with a tube or tracheostomized patients ventilated with bilevel positive airway pressure (BIPAP) or assisted spontaneous ventilation (ASV). Mean sedative or analgesic medication for a patient with 70 kg body weight within 24 h were as follows: 180 mg midazolam, 5.5 mg sufentanil, 3240 mg propofol, and 10 mg remifentanil. To compensate for annual price fluctuation, sedation costs were calculated for every year separately with the given price of the pharmacy in house.

Unless otherwise stated, all costs are given in Euros.

2.3. Statistical analysis

Statistical computations were performed using the open source statistical package R version 3.1.1 (© 2014 The R Foundation for Statistical Computing, http://www.r-project.org). The two groups (Group A received sufentanil and midazolam, Group B received propofol and remifentanil) were compared regarding their base parameters. The main outcome parameter was days of ICU stay. The ICU stay was estimated in univariate negative and multivariate binomial count regression models (NegBin II). Count regression models are multiplicative models of the form *regressand* $\sim e^{intercept+\beta 1+\beta 2+\beta 3} \sim e^{intercept} \times e^{\beta 1} \times e^{\beta 2} \times e^{\beta 3}$. Thus, the estimated β values may easily be interpreted. β Values of less than zero decrease the ICU stay ($e^{\beta>0} < 1$) and those greater than zero increase the ICU stay ($e^{\beta>0} > 1$).

The principal anesthesiologic regressor was defined as the sedation protocol. Surgical confounders were defined as tracheostoma, tumor resection, neck dissection, and microvascular reconstruction. Patient confounders were age, sex, and logarithm of the SAPS II. Since the minimum ICU stay is standardized by an interinstitutional protocol as 2 days, an offset of 2 was defined in the NegBin II models.

3. Results

3.1. Patient characteristics

A total of 157 patients (146 OSCC, 6 ameloblastoma, 1 odontogic clear cell carcinoma, 1 sarcoma, 3 metastasis of distant carcinoma) were included in this study. Of these, 84 patients (58 male, 26 female, aged 57.6 ± 10.6 years, range 23.8–80.9 years) were sedated using midazolam and sufentanil, and 73 patients (47 male, 26 female, aged 60 ± 10.4 years, range 32.1–80.7 years) using propofol and remifentanil were included. The only confounder that showed a significant group difference was tracheostoma (Table 1).

3.2. Sedation protocol and length of artificial ventilation or ICU stay

As depicted in Fig. 1, patients receiving midazolam and sufentanil stayed 9.2 ± 6.2 days [range: 2–28] in the ICU, and patients