Clearance of bronchial secretions after major surgery
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Summary

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- Chapter 1

Post-operative pulmonary complications were identified as early as 1910. Post-operative lung collapse was identified as the result of occlusion of the airways by mucus. Subsequent work reported the findings of post-operative hypoxia and lung collapse by shallow breathing after laparotomy. Notwithstanding subsequent advances in surgery and supportive medications, the morbidity resulting from post-operative pulmonary abnormalities, remains a significant problem. The proposed mechanisms for pathogenesis of post-operative pulmonary abnormalities have altered little since early 20th century. There are still two basic theories to explain their occurrence: regional hypoventilation and stasis of mucus. Pathological changes in breathing pattern and in ability to mobilize mucus are described in this chapter.

Contributing factors of hypoventilation in the pre-operative phase are: Increasing age, Obesity and Malnutrition, Cigarette smoke and Chronic Obstructive Pulmonary Disease. During surgery, general anesthesia and the site of surgery are important elements leading to airway closure. Post surgery, the severity of pain may depend on the type and site of surgery, the age of the patient and the individual’s response to stress of the operation, a patient’s personality, previous pain experience, cultural background, and conditioning.

MacMahon described one of the earliest publications regarding increasing inspiratory effort through breathing exercises and manual control during expiratory maneuvers such as coughing, in 1933. Nowadays, reviews of the well-recognized physiological changes of the post-operative period are present. They describe empirical support for the role of physiotherapy treatment to prevent or minimize hypoventilation and secretion plugging.

During intubation, endotracheal suctioning is used to prevent secretion plugging in the trachea and large bronchi. The American Association for Respiratory Care described a consensus guideline in performing endotracheal suctioning in 1993. Many indications are named in this guideline: coarse breath
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sounds or noisy breathing, increased peak inspiratory pressures or decreased tidal volumes, visible secretions in the airway, changes in flow or pressure, suspected aspiration, clinically increased work of breathing, deterioration of arterial blood gas values, radiological changes consistent of mucus retention, the need to obtain a sputum specimen, the need to maintain patency and integrity of the artificial airway, the need to stimulate a cough, and the presence of pulmonary atelectasis or consolidation. Patient monitoring should consist of auscultation, interpretation of vital signs, pulse rate, blood pressure, respiratory rate or pattern, cough effort, sputum characteristics and ventilator parameters. These clinical “data” should be monitored prior, during and after endotracheal suctioning to indicate and evaluate the procedure. Endotracheal suctioning may have undesired adverse effects: several studies report cardiac arrhythmia and oxygen desaturation during suctioning. To counteract the adverse effects manual hyperinflation is used. This technique describes hyperventilation with a resuscitation bag by an increased rate and/or tidal volume.

After the intubation, phase patients need to maintain sufficient lung volume to avoid pulmonary complications. To maintain sufficient lung volume deep-breathing exercises could be used to increase the level of breathing above closing capacity, a level where airways collapse. Incentive spirometry was developed to stimulate the patient to perform deep-breathing exercises under supervision or independently. The cardiovascular and respiratory effects of immobility and bed rest have been well documented. These include reduced lung volumes and capacities, especially functional residual capacity, reduced \( P_{a}O_{2} \), decreased \( VO_{2} \text{ max} \), cardiac output, and stroke volume, increased heart rate, and orthostatic intolerance.

With respect to expiratory techniques like huffing and coughing, little research exists that compares efficacy of mucus-mobilizing techniques in the post-operative phase. Post-operative mucus clearance in patients after high-abdominal and thoracic surgery is daily routine. Our daily routine needs to be evaluated especially during and after the intubated phase.
Chapter 2

Endotracheal suctioning in intubated patients is routinely applied in most ICUs, but may have negative side effects. Our study objective was to investigate the effect of routinely versus minimally invasive airway suctioning. We hypothesized that on-demand minimally invasive suctioning (MIAS) would have fewer side effects than deep routine endotracheal suctioning (RES), and would be comparable in duration of intubation, length of stay in the ICU and ICU mortality. In a randomized prospective clinical trial on two ICUs at University Hospital Groningen, 383 patients requiring endotracheal intubation for more than 24 hours were included. RES (n=197) using a 49 cm suction catheter was compared with on demand MIAS (n=186) using a suction catheter of only 29 cm long.

No differences were found between the RES group and the MIAS group in duration of intubation, ICU-stay, ICU mortality and incidence of pulmonary infections. Suction related adverse events occurred more frequently with RES interventions than with MIAS interventions: decreased saturation; increased systolic blood; increased pulse pressure rate and blood in mucus.

This study demonstrates that MIAS in intubated ICU patients has fewer side effects than deep RES, without being inferior in terms of duration on intubation, length of stay and mortality.

• Chapter 3

Many patients have an unpleasant recollection of routine endotracheal suctioning (RES) after discharge from the Intensive Care Unit (ICU). We hypothesized that through minimally invasive airway suctioning (MIAS) discomfort and stress may be prevented, resulting in less recollection. In a prospective randomized clinical trial on two ICUs at the University Hospital of Groningen, adult patients with an intubation period exceeding 24 hours were included. Patients received either RES or MIAS during the duration of intubation.
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Within three days after ICU discharge, all patients were interviewed, regarding recollection and discomfort of suctioning. The level of discomfort was quantified on a visual analogue scale (VAS).

We analyzed data from 208 patients (RES: n=113 and MIAS: n=95). A significantly lower prevalence of recollection of airway suctioning was found in the MIAS group compared to the RES group. No significant difference in level of discomfort was found between the RES and the MIAS group. MIAS results in a lower prevalence of recollection of airway suction than in RES, but not in discomfort.

• Chapter 4

Routine endotracheal suctioning (RES) was shown to increase systolic blood pressure and increase pulse-pressure rate suggestive of stress. This study was designed to test the hypothesis that minimally invasive airway suctioning (MIAS) evokes a less pronounced stress response than RES.

Intubated stable ICU patients were eligible for participation in this study. Exclusion criteria were noradrenaline or adrenaline infusion for the last 24 hours, the use of steroids and age under 55 or over 80 years. In a cross-over design either RES or MIAS was applied. Arterial blood samples were collected prior to (T0), 1 minute after (T1) and 15 minutes after the suctioning procedure (T15) making use of an arterial access. After a washout period of three hours the second intervention of the crossover design, either MIAS or RES, was performed. Blood samples were analyzed for noradrenaline, adrenaline and cortisol levels.

In this study 16 patients were included. All patients underwent one episode of RES and one episode of MIAS, in random order. Baseline levels of noradrenaline, adrenaline and cortisol were elevated. In the RES group, a significant rise in noradrenaline and cortisol between T0 and T1 was observed. No such rise was seen in the MIAS group. Adrenaline levels were not significantly influenced in either group.

RES caused a significant increase in noradrenaline and cortisol response compared to the MIAS intervention which suggests that RES leads to higher stress levels. RES may be a more stressful intervention than MIAS.
Chapter 5

Retrospective assessment of discomfort is difficult because recollection of stressful events may be impaired by sedation and severe illness during the ICU period. The purpose of this study was to investigate the following questions: a) what was the incidence of discomfort reported by patients recently discharged from the ICU, b) what were the sources of discomfort reported, c) what was the factual recollection of their stay on the ICU and d) was discomfort reported more often in patients with good factual recollection?

All ICU patients older than 18 years who had needed prolonged admission with tracheal intubation and mechanical ventilation were included consecutively into the study. Within three days after discharge from the ICU, a structured face-to-face interview with each individual patient took place. All patients were asked to answer a questionnaire consisting of 14 questions specifically concerning the environment of the ICU they had stayed on. Furthermore, they were asked whether they remembered any discomfort during their stay and if so, which sources of discomfort they could recall. A reference group of surgical ward patients, matched by gender and age to the ICU group was studied to validate the questionnaire.

In this study 125 patients, discharged from the ICU, were included. Data of 123 ICU patients and 48 ward patients were analyzed. The prevalence of any type of discomfort in the ICU patients was 54%. These 66 patients were asked to identify the sources of discomfort. The presence of an endotracheal tube, hallucinations and medical interventions were identified as sources of discomfort. The median (min-max) score for factual recollection in the ICU patients was 15 (0-28). The median (min-max) score for factual recollection in the reference group was 25 (19-28). Analysis showed that discomfort was positively related to factual recollection, especially discomfort caused by the presence of an endotracheal tube, medical activities and noise. Hallucinations were reported more often with increasing age. Younger patients predominantly reported pain as a source of discomfort.
Decline in pulmonary function after major abdominal surgery is thought to be identified in daily assessment by observation of breathing and pain intensity. Measurement of pulmonary function is usually not included in the assessment of the patient in the post-operative period. The aim of this study was to investigate the relationship between clinical observation of breathing (COB), pain intensity and decline in pulmonary function.

In our study 89 patients participated, after being admitted for elective major mid- and upper-abdominal surgery. COB covered the following parameters: Abdominal expansion, Side expansion, High thoracic expansion, Paradoxical breathing, Symmetry of thorax expansion, Ability to cough, Ability to huff and Signs of mucus retention. Pain intensity was assessed using a visual analogue scale (VAS). FEV₁, FVC and PEFR were performed on the pre-operative day and for seven post-operative days.

A poor correlation is found between clinical observation of breathing and pulmonary function or pain after abdominal surgery.

The general discussion briefly describes the main points of this thesis. Minimally invasive airway suctioning is equally effective as routine endotracheal suctioning but results in less suction related adverse events, less recollection of suctioning and less stress. Thus, although it cannot be employed in all situations, minimally invasive airway suctioning should be the “default setting” for mucus clearance in ICU-patients. Special suction catheters should be marketed that do not pass the distal tip of the endotracheal tube. Alternatively, standard catheters can be marked to avoid too distal routine suctioning.

An ICU can be considered a stressful environment, which may lead to unpleasant memories. It is as yet unclear how these can be avoided. Deeper sedation with standard drugs is not the answer as it increases the incidence of post-traumatic stress syndrome in the aftermath of a period on the ICU. A
multidisciplinary team approach for patients discharged after a prolonged stay on the ICU may be appropriate.

After discharge of patients from the ICU to the ward, current assessment of pulmonary function seems to be inadequate. Actual measurement of pulmonary function with a handheld spirometer should be implemented on the third day post surgery to evaluate possible pulmonary complications.