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Implementation of a pneumonia prevention protocol to decrease the incidence of postoperative pneumonia in patients after hip fracture surgery

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ABSTRACT

Objective: Postoperative pneumonia is among the most common complications in elderly patients after hip fracture surgery. We implemented a proactive postoperative pneumonia prevention protocol and analyzed the incidence of postoperative pneumonia in elderly patients (≥70 years of age) receiving this protocol after hip fracture surgery versus those receiving usual care before the protocol's implementation at our institution.

Materials and Methods: From November 2018 to October 2019, the proactive postoperative pneumonia prevention protocol was implemented. The treatment included intensified physical therapy, postoperative pulmonary exercises and oral care, in addition to the usual surgical treatment for elderly patients with hip fracture. The intervention cohort data were compared with a historical control cohort treated from July 2017 to June 2018. The primary outcome of this study was the incidence of postoperative pneumonia in both groups, diagnosed according to the presence of two of three of the following: elevated infection parameters, radiologic examination confirmation of pneumonia of the chest or clinical suspicion.

Results: A total of 494 patients (n= 249 in the historical control cohort and n=245 in the intervention cohort) were included. A total of 69 patients developed postoperative pneumonia. The incidence of postoperative pneumonia was significantly lower (6.7 percentage points) in the group receiving the proactive postoperative pneumonia prevention protocol (17.3% in the historical control cohort vs 10.6% in the intervention cohort; p=0.033).

Discussion and Conclusion: A proactive postoperative pneumonia prevention protocol showed promise in decreasing the occurrence of postoperative pneumonia after hip fracture surgery in elderly patients.

Introduction

In the Netherlands, approximately 17.500 patients with hip fracture are admitted to a hospital each year [1]. Hip fractures often occur in medically frail patients and substantially affect health status. These fractures are associated with higher short- and long-term all-cause mortality [2–4]. In addition, functional recovery is not optimal in a substantial proportion of these patients. One year after hip fracture surgery, one-third of patients do not regain their pre-injury ambulation status or their level of functioning in activities of daily living [5,6]. The ability of patients to resist or recover functional ability as a result of a stressor or disruption, such as a hip fracture, is also referred to as resilience. The occurrence of complications could be considered additional stressors beyond the hip fracture, thus substantially affecting patients' resilience. Postoperative pneumonia is among the most common complications in frail patients with hip fracture [7–9].

Data from the Centre for Geriatric Traumatology (CvGT) of the Department of Trauma Surgery at Ziekenhuisgroep Twente (ZGT, a teaching hospital with 755 hospital beds located in Almelo, the Netherlands) have shown an increase in the number of patients with postoperative pneumonia (14.3% in 2017 compared with 12.5% in 2016), which is probably attributable to the adoption of the

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Abbreviations

ASA	American Society of Anesthesiologists physical status classification
CCI	Charlson Comorbidity Index
CvGT	Centre for Geriatric Traumatology (CvGT) at Ziekenhuisgroep Twente (ZGT) location Almelo
HAP	hospital acquired pneumonia
VAP	ventilator-associated pneumonia
ICOUGH	acronym of *i*ncentive spirometry, *c*oughing and deep breathing, *o*ral care, *u*nderstanding, *g*etting out of bed and *h*ead-of-bed elevation.
IQR	Interquartile range
SD	Standard deviation
ZGT	Ziekenhuisgroep Twente Almelo-Hengelo

proactive identification approach because of the recognized importance of early treatment of pneumonia.

Early mobilization and postoperative pulmonary exercises are recommended non-pharmacological interventions for the prevention of postoperative pneumonia. Stahl et al. and Chang et al. have shown a decrease in postoperative pneumonia incidence after intensified physical therapy in patients with hip fracture [10,11]. Moreover, in the search for solutions for more effective prevention protocols to decrease the incidence of postoperative pneumonia, several studies have shown beneficial effects of an oral hygiene protocol [10–16].

Poor oral health can lead to high counts of microorganisms in dental biofilm and periodontal pockets; these microorganisms can enter the trachea and lungs and result in pulmonary infection [17–22], as indicated by studies showing a similarity between the microbiota in oral and respiratory samples and in hospital acquired pneumonia [23–25]. Quin et al. have shown a 37% decrease in pneumonia during a 12-month enhanced basic oral nursing care intervention period in hospitalized patients. Consequently, addition of an oral hygiene protocol to the previously described intensified physical therapy protocol was suggested [15].

In 2013, Cassidy et al. implemented a pneumonia prevention protocol, called ICOUGH, combining lung expansion, early and frequent mobilization, oral care and education. Implementation of ICOUGH for a duration of 1 year in the care of patients of all ages receiving vascular and general surgery encouragingly decreased the postoperative pneumonia incidence from 2.6% to 1.6%, and the odds ratio from 2.13 to 1.58 [16]. To date, no empirical data are available on the outcomes of a pneumonia prevention protocol combining early mobilization, postoperative pulmonary exercises and oral care in elderly patients after hip fracture surgery. Therefore, the objective of our study was to analyze the effects of implementation of a proactive postoperative pneumonia prevention protocol on the incidence of postoperative pneumonia in elderly patients after hip fracture surgery compared with a historical usual care control cohort.

Methods

Study design

Patients with hip fracture who had been treated surgically at the CvGT between November 2018 and October 2019 were included in this intervention cohort study. To compare outcomes, we used a historical control cohort of patients treated at the CvGT at ZGT between July 2017 and June 2018. The timespan between the historical control cohort and intervention cohort study was used to introduce and implement the pneumonia prevention plan in daily healthcare. This study was approved by the medical research ethics committee.

Pneumonia prevention protocol

Before the study, a taskforce consisting of healthcare professionals working at the clinical ward was asked to provide input regarding the clinical feasibility of the prevention plan during the 3-month implementation process. In addition, oral healthcare information lectures were held for geriatric traumatology nurses and supportive healthcare workers. During admission, patients and family members were informed by the nurse about the study, posters were displayed in the ward of the CvGT, and patients also received an information leaflet.

On day 1 postoperatively, a Voldyne® 5000 Incentive Spirometer (Hudson RCI, Temecula, California USA) was offered by the physiotherapist on the ward, and a one-time explanation of the total protocol was given. Nurses and care assistants provided instructions on how to use the Voldyne and motivated patients on cough/deep breath prompts every 2 hours. In addition, oral care was implemented (twice per day by brushing teeth or dental prosthesis), and the head of the bed was elevated $> 30^{\circ}$ upward. The physiotherapist together with the nursing staff ensured frequent mobilization. Physical therapy was provided at least twice per day, and was adjusted to the needs and capacity of each patient (for example bed-chair mobilization or walking with a frame).

To emphasize the importance of the prevention plan and to prevent relapse, a nursing assignment in the electronic health record was given regularly as a reminder by the doctor or nurse specialist. The protocol was embedded in daily care, with no additional checklists or personnel scheduled. No taskforce meetings were scheduled after the protocol was fully implemented, and no verification of the researcher's implementation of the protocol was performed. The associated costs were low, at only €2.08 per patient for the Voldyne® 5000 Incentive Spirometer.

The outcome of postoperative pneumonia was recorded when antibiotics were started for clinically diagnosed pneumonia after hip surgery and when at least two of three of the following pneumonia findings were confirmed:

- elevated infection parameters: leukocytosis ($> 10^9$/L) and elevated C-reactive protein (>50 mg/L)
- confirmation of pneumonia through radiologic examination of the chest
- clinical suspicion of pneumonia (fever, purulent sputum, worsening cough, dyspnea or tachypnea, rales or rhonchi, worsening gas exchange or altered mental status with no other cause)

Data collection

Historical control and intervention cohort database analyses were conducted through clinical chart review of the included patients. The following patient baseline characteristics were recorded: age, sex, type of fracture, type of surgery, American Society of Anesthesiologists physical status classification (ASA, 1: normal healthy patient, 2: patient with mild systemic disease, 3: patient with a severe systemic disease that is not life-threatening, 4: patient with severe systemic disease posing a constant threat to life) [26], medical history, previous admission for pneumonia, Charlson Comorbidity Index (CCI) adjusted with 1 point added for every decade of age 50 years and above, with a maximum of 4 points (mild, scores of 1–2; moderate, scores 3–4; and severe, scores ≥5) [27,28], dementia, prefracture KATZ-ADL6 score (score of 6: high, patient is independent; score of 0: low, patient is highly dependent) [29], SNAQ score (score of 0 –1: low risk of malnutrition; score of 2: moderate risk of malnutrition; score

Table 1
Baseline patient characteristics

	Total (n=494)	Intervention cohort (n= 245)	Historical control cohort (n= 249)	P- value
Age (years); mean (SD)	83.6 (6.55)	83.5 (6.38)	83.6 (6.73)	0.822
Female gender; n (%)	359 (72.7)	182 (74.3)	177 (71.1)	0.425
Type fracture; n (%)				0.381
Neck of femur	257 (52.0)	121 (49.4)	136 (54.6)	
Pertrochanteric	225 (45.5)	119 (48.6)	106 (42.6)	
Subtrochanteric	12 (2.4)	5 (2.0)	7 (2.8)	
Type of operation; n (%)				0.532
Hemiarthroplasty	190 (38.5)	88 (46.3)	102 (52.7)	
Proximal femoral Nail Antirotation (PFNA)	238 (48.2)	123 (51.7)	115 (48.3)	
Dynamic hip screw	60 (12.1)	32 (53.3)	28 (46.7)	
Cannulated screws	6 (1.2)	2 (33.3)	4 (66.7)	
ASA; n (%)				0.379
1-2	187 (37.9)	88 (35.9)	99 (39.8)	
3-4	307 (62.1)	157 (64.1)	150 (60.2)	
CCI score; median (IQR)[1]	5 (4.0-6.0)	4.0 (4.0-5.0)	5.0 (4.0-6.0)	0.191
KATZ-ADL6 score; median (IQR)[2]	1.0 (-1.0 – 3.0)	1.00 (-1.0 - 3.0)	1.00 (-1.0 – 3.0)	0.972
Dementia; n (%)	85 (17.2)	40 (16.3)	45 (18.1)	0.607
Smoking; n (%)	48 (9.7)	19 (7.8)	29 (11.6)	0.144
SNAQ score; median (IQR)[3]	0.0 (-1.0 - 1.0)	0.0 (-1.0 – 1.0)	0.0 (-1.0 – 1.0)	0.286
Prefracture mobility score; n (%)				**<0.001**
Freely mobile without aids	189 (38.3)	99 (40.0)	90 (36.1)	
Mobile outdoors with one aid	45 (9.1)	33 (13.5)	12 (4.8)	
Mobile outdoors with two aids or frame	163 (33.0)	63 (25.7)	100 (40.2)	
Some indoor mobility but never goes outside without help	89 (18.0)	48 (19.36)	41 (16.5)	
No functional mobility (using lower limbs)	8 (1.6)	2 (0.8)	6 (2.4)	
Prefracture living situation; n (%)				0.633
Independent	206 (41.7)	99 (40.4)	107 (43.0)	
Independent with help	172 (34.8)	90 (36.7)	82 (32.9)	
Care home	29 (5.9)	17 (6.9)	12 (4.8)	
Geriatric rehabilitation centre	10 (2.0)	5 (2.0)	5 (2.0)	
Nursing home	77 (15.6)	34 (13.9)	43 (13.9)	

[1] Range 0-24
[2] Range 0-6
[3] Range 0-4, ASA, American Society of Anesthesiologists physical status classification; CCI, Charlson Comorbidity Index; SD, standard deviation; IQR, interquartile range with Q1 25th percentile and Q3, 75th percentile; n, number of patients. Differences in baseline characteristics between the intervention cohort and historical control cohort were tested.

of ≥ 3: high risk of malnutrition) [30], prefracture mobility score [31], prefracture living situation, discharge destination, length of hospitalization, smoking, alcohol abuse, complications during admission, medication (antiacids, immunosuppressive agents, atomization pre-hospital and during admission, antibiotics and antipsychotic agents) and occurrence postoperative pneumonia (day of admission, diagnosis and type of antibiotics).

Outcomes and statistical analyses

Statistical analyses were performed in SPSS Statistics V22.0 software (SPSS Inc., North Chicago, IL, USA). Categorical variables are presented as numbers and corresponding percentages. Normally distributed continuous variables, on the basis of interpretation of histograms, are presented as mean with standard deviation; continuous variables not normally distributed are presented as median with interquartile range. Testing of associations was performed with two-tailed independent sample T-tests or Mann-Whitney U tests as appropriate for continuous variables, and chi-square tests for categorical variables. A p value <0.05 was considered statistically significant. Variables associated with the cohorts with $p<0.15$ were subsequently tested for association with pneumonia and were considered potential confounders when $p<0.15$.

Results

Patient characteristics

A total of 494 patients with a surgically treated hip fracture were included. Baseline characteristics are shown in Table 1. The mean age was 83.6 years (standard deviation 6.5), and 72.7% (n=359) of the patients were women. In 52% of the total population, the type of fracture was a neck of femur fracture. The median CCI score was 4.0 (4.0–5.0) in the intervention cohort and 5.0 (4.0–6.0) in the historical cohort, corresponding to a moderate and severe risk of mortality, respectively [32].

No significant differences were observed between the intervention cohort and historical control cohort, except that the prefracture mobility score was higher in the intervention cohort than the historic control group. No significant differences were observed in prefracture living situation and KATZ-ADL6, an index of independence in activities of daily living.

Postoperative pneumonia

A total of 69 (14.0%) patients were diagnosed with postoperative pneumonia, as shown in Table 2. A significant difference in the incidence of the postoperative pneumonia was observed between the intervention cohort and the historical control cohort (10.6% and 17.3%, respectively; p=0.033). No difference was observed in the day of diagnosis of pneumonia between groups.

The prefracture mobility score and smoking at baseline were univariate associated with the risk of pneumonia in both cohorts ($p<0.15$). However, no relationship was found between the variables and pneumonia; thus, no confounding was observed.

Discussion

Postoperative pneumonia is among the most common complications in surgery and is associated with elevated morbidity and mortality [33]. Within the CvGT, founded at ZGT, patients ≥ 70

Table 2
Incidence of postoperative pneumonia

	Total (n=494)	Intervention cohort (n= 245)	Historical control cohort (n= 249)	P- value
Postoperative pneumonia; n (%)	69 (14.0)	26 (10.6)	43 (17.3)	0.033
Postoperative day of diagnosis pneumonia; median (IOR)	3 (1.5-4.5)	2 (1-3)	3 (1.5-4.5)	0.132

Index; IQR, interquartile range with Q1, 25th percentile and, Q3, 75th percentile; n, number of patients, Differences in characteristics between the intervention cohort and historical control cohort were tested.

years of age are treated according to a multidisciplinary orthogeriatric treatment model, to prevent or limit complications and loss of function to the greatest extent possible [7,12,13]. Many advances have been made in preventing postoperative pneumonia in patients with hip fracture, including intensified physical therapy treatment, postoperative pulmonary exercises and oral care [12–16,34,35]. To our knowledge, combining these prevention strategies after hip fracture surgery, as conducted in this study, is unique. This single-center study reveals promising results for a combined postoperative pneumonia prevention protocol in preventing postoperative pneumonia after hip fracture surgery in elderly patients: the incidence of postoperative pneumonia significantly decreased by 6.7 percentage points.

This proactive postoperative pneumonia prevention study consisted of intensified physical therapy treatment, postoperative pulmonary exercises and oral care. Together, these treatments are considered minimally disruptive to daily routine activities, thus lowering the barriers to their sustainable implementation and increasing the protocol's potential. However, with this protocol, 10.6% of the patients still developed post-operative pneumonia. To further decrease this percentage, addressing dysphagia might be worthwhile. Dysphagia in older people is significantly associated with the incidence of pneumonia in literature [36–38]. Wijnen et al. have shown a high prevalence (34%) of swallowing disorders after hip fracture surgery in frail elderly patients. These findings resulted in the introduction of dysphagia analysis and subsequent precautionary actions [39]. Therefore, dysphagia screening and interventions such as maintaining an upright sitting position while eating might be an interesting addition to the postoperative pneumonia prevention protocol.

Early surgery is another important aspect that might further decrease post-operative pneumonia. Research has indicated that early surgery is associated with decreased mortality and postoperative complications in patients with hip fracture, thus suggesting that delayed surgery might be a possible risk factor for developing postoperative pneumonia [40]. In this study, possible risk factors, such as a delay in surgery, were not investigated. However, the median number of days from admission to operation was 1.0 (0.0–2.0) day, and 94.1% of the patients was treated within 48 hours; thus, delayed surgery was probably not a major risk factor in this study. In addition, one multi-center study in the United States and one single-center study in China have revealed the following additional risk factors for postoperative pneumonia in patients with hip fracture: male sex, older age (particularly ≥90 years), ASA ≥III, anemia, diabetes mellitus and chronic obstructive pulmonary disease [41,42]. Although these factors cannot be changed either on short notice or at all, knowledge regarding these risk factors is important for better and earlier identification of the patients most at risk. These patients may particularly benefit from a proactive and personalized approach.

In this study, no distinction was made between hospital acquired pneumonia (developing 48 - 72 h after admission) and ventilator-associated pneumonia (developing 48 - 72 h after endotracheal intubation) nosocomial pneumonia, because they cannot be clinically distinguished, given that studies have shown similarities in their primary pathogens and comparable results of empirical therapy for both [43–45]. However, a difference exists between nosocomial pneumonia and community acquired pneumonia in causative pathogens and empirical therapy. Because no distinction was made between them in this study, community acquired pneumonia might potentially have been included. Nonetheless, this possibility was unlikely, because the median day of diagnosis of postoperative pneumonia was 2 days after the operation.

Limitations

In this study, the comparison of the intervention cohort group with a historically measured usual care group resulted in limitations of poor control over the exposure factors, covariates and potential confounders in the historical control cohort. Nevertheless, confounding was not observed. In this study no interference of the researcher with the implementation of the study protocol occurred; however, better compliance with the protocol and task force-driven optimization of the protocol would probably have led to a lower incidence of postoperative pneumonia in this study. Nonetheless, the results provide a good reflection of the outcomes that can be achieved in daily practice. The findings are promising, given that the intervention is a minimally intensive daily routine. Cognitive bias by the medical staff might have compromised the validity, because the medical staff could have assumed a positive effect of the prevention protocol and consequently a higher threshold to pneumonia diagnosis than in the historically measured usual care cohort, thus resulting in less pneumonia being recorded in the intervention cohort.

Conclusion

Postoperative pneumonia is a severe complication after hip fracture surgery in elderly patients. A proactive postoperative pneumonia prevention protocol including intensified physical therapy treatment, pulmonary exercises and oral care showed promising results in preventing pneumonia after hip fracture surgery, leading to a significant 6.7 percentage point decrease in the incidence of postoperative pneumonia in the intervention cohort. Implementation of this protocol may prevent further deterioration of health status and markedly improve the health of hospitalized patients in terms of decreasing morbidity and mortality.

Conflicts of Interest

None declared.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.injury.2022.06.017.

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