Does reduced cough capacity in minor thoracic injury is associated with atelectasis development?

Sandrine Hegg
Centre de recherche du Centre Hospitalier Universitaire (CHU) de Québec. Québec. Canada
Brice Batomen
Centre de recherche du Centre Hospitalier Universitaire (CHU) de Québec. Québec. Canada
Esther Thériault
Faculté de médecine. Université Laval. Québec. Canada
Valérie Boucher
Centre de recherche du Centre Hospitalier Universitaire (CHU) de Québec. Québec. Canada
Marcel Émond (marcelemond1@me.com)
Centre de recherche du Centre Hospitalier Universitaire (CHU) de Québec. Québec. Canada

Research Article

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Abstract

Context: Minor thoracic injury causes non-negligible pain that could reduce the cough capacity and can cause infectious problems and atelectasis.

Objectives: To describe the association between atelectasis and cough capacity, and to assess the concordance of cough capacity perceptions between health professionals and the patient.

Design:The data were collected from 2006 to 2012 in 4 Canadian emergency departments (ED).

Participants: Patients with a chief complaint of minor thoracic injury, ≥ 16 years old, discharged home from the ED after an evaluation by the attending physician, were included. They have three visits, at the ED, 7-day and 14-day follow-up. The initial ED visit included medical evaluation, data collection and mandatory chest and rib radiography.

Main outcome measures: The presence of atelectasis was noted at the initial ED and subsequent visits.Participants cough capacity was noted by a physician, a nurse and the patients himself at subsequentvisits and classified as good, diminished, weak /absent.

Results: Among the 1474 patients, 8.89% (95% CI: 7.55 - 10.47), 7.33% (95% CI: 6.04 – 8.89) and 4.63% (95% CI: 3.51 – 6.09) had atelectasis at the initial visit, 7-day and 14-day follow-up visit respectively. Except for patients with weak or absent cough capacity at the 7-day visit, which had a 2.89 (95%CI: 2.05 – 4.05) folds atelectasis proportion relative to those with a good cough capacity, they were no associations between cough capacity and atelectasis. The weighted kappa coefficient suggests a moderate to substantial agreement between the cough capacity measured by patients and nurses (0.52 to 0.65).

Conclusion: There was not strong evidence of an association between atelectasis and cough capacity and the best agreement between cough capacity perception was between nurses and patients.

Introduction

Minor thoracic injury's(mTI) are defined by the presence of chest abrasion, chest contusion or minor rib fractures(1, 2). These injuries account for approximately 15% of all injuries treated in the emergency department, many of which will be treated on an outpatient basis(3). They have also been associated with a high risk of morbidity and mortality and complications such as delayed pneumothorax, hemothorax and pneumonia have been reported(1, 4, 5). It is also known that patients with mTIs and rib fractures can experience non-negligible pain(1, 2, 6, 7), which can lead to reduced pulmonary function, decreased mucous clearance and decreased cough capacity(4, 8-12). Coughing is a normal mechanism of the body that allows the airway to remain free of foreign objects and to expel secretions produced by the lungs(10). When impaired, cough can cause infections and atelectasis(10, 11, 13). Atelectasis is a collapse of a major lung segment and can occur when the residual functional capacity is lower than the

volume at which dependent airways close (14, 15). Ineffective clearance of secretions is one of the predisposing factors of this pathology(14). Low tidal volumes also encourage the progressive lung collapse (14, 15). Therefore, the pain syndrome caused by mTI can induce low cough capacity and Atelectasis. Thus, if it were possible to effectively assess the cough capacity of these patients in the emergency department (ED), this might help practitioners prevent atelectasis. To our knowledge, there is no study evaluating cough capacity and its relationship with atelectasis development in patients with mTI at the ED.

Therefore, the primary objective of this study was to describe the association between cough capacity and the incidence of atelectasis in patients with a chief complaint of mTI. The secondary objective was to assess the concordance of cough capacity perception between health professionals and the patients themselves.

Methods

Setting:

This is a secondary analysis of a prospective multicenter observational cohort study that took place between November 2006 and May 2012 in four Canadian university affiliated emergency departments (ED),two of which were level I trauma centers, one level II trauma center and one academic non-trauma center(16).

Participants and recruitment:

Discharged patients aged ≥ 16 who presented to the ED with a chief complaint of mTI were included. Patients were excluded if they had: a confirmed hemothorax, pneumothorax, flail chest, lung contusion or any other important thoracic or internal abdominal injury upon initial visit. Patients who were unable to attend follow-up visits, unable to consent, and those who presented to the ED more than 3 days after the initial trauma were excluded as well.

Procedure and measures:

After informed written consent was obtained, an index medical evaluation was performed by the attending physician or delegate. Relevant sociodemographic and clinical data, such as age, sex, mechanism of injury, dyspnea, COPD, asthma, oxygen saturation and smoking status were collected and patients underwent a chest and rib radiography.

Patients returned for 7- and 14- day in person medical evaluations, during which they underwent follow-up chest radiographies to evaluate the presence of atelectasis and other complications such as pneumothorax or hemothorax. These evaluations also included pain assessment and clinical examinations performed by a physician and the data collected was recorded on a standardized data collection sheet.

Radiologists who were blinded to the study's objectives assessed each chest x-rays and determined whether a patient had developed atelectasis using the standard radiological criteria for its diagnosis. Cough capacity was assessed with a multiple-choice question (QCM) by the physician, a nurse and the patient himself at 7 and 14 days. The QCM was described as good/normal decreased, low/absent. Patients also self-assessed their chest pain using the visual Visual Analog Scale (VAS) pain (0: no pain. 10: extreme pain) at each visit.

Statistical analysis:

Multiple imputation with chained equation was used for imputing missing values of patient characteristics at the initial visit and cough capacity(17)**.**We used censoring weights (IPCW)to account for the loss to follow-up. The aim was to weight each subject by their inverse probability of having each measurement observed (i.e. that they have not yet dropped out)(18).

These weights were then used in a generalized estimating equation GEE accounting for data clustering to compute relative proportion of atelectasis within each cough capacity level at each visit adjusted for age, sex, dyspnea and smoking history (19). To assess the agreement between the cough capacity perception according to the patient or health professionals, we used the weighted kappa coefficients (20). The following standards were used as strength of agreement, a kappa coefficient ≤0=poor, 0.01–0.20=slight, 0.21–0.40=fair, 0.41–0..60=moderate, 0.61–0.80=substantial, and 0.81–1=almost perfect(21).

All analyses were stratified according to the presence or absence of atelectasis at the initial visit and statistical tests were adjusted for multiple comparisons. Rubin's rule was used to combined results across imputed datasets(22).

Ethics approval:

This study was approved by the research ethics committee of each institution.

Results

A total of 1474 patients were enrolled. Among those,14% (n=213) of patients did not attend their 7-follow-up appointment and 23% (n=341) at 14days.The mean age of participants was 54.48 years, male represent two third of the study population and fall from height was the most common mechanism of injury. All characteristics of participants are presented in **Table 1**.Among the 1474 patients,8.9% (95% CI: 7.55-10.47) had atelectasis at the initial visit. Accounting for losses to follow-up with IPCW, we estimated that the proportion of atelectasis was 7.3% (95% CI:6.04 - 8.89)and 4.6%(95% CI:3.51 - 6.09), respectively at 7 and 14 days.

Table 2 presents association between cough capacity and atelectasis development. Compared with patients with good self-reported cough capacity, those with low or decreased capacity seemed to have a higher proportion of atelectasis. This pattern was higher at the 7-day follow-up for patients without atelectasis at the initial visit, relative proportions of 2.89 (95% CI 1.93 - 4.33).

The cough capacity improves between the 7- and 14-day follow-up for patients with and without atelectasis. That improvement was mostly due to the fact patients with low or diminished cough capacity at 7 day had a good cough capacity at the 14-day visit(**Table 3**).We also observed a decreased in the means of pain at each follow-up (**Table 4**).

The weighted kappa coefficient suggests a moderate to substantial agreement between the cough capacity measured by patients and nurses (0.52 to 0.65); and a fair agreement between patients and physicians (0.33 to 0.42) (**Table 5**).

Discussion

In this descriptive study, we did not find a strong evidence of an association between atelectasis and cough capacity, except at the 7-day follow-up for patients without atelectasis at the initial visit. However, the 95% confidence intervals were wide, and we lacked precision to make any conclusion. In addition, we observed a decreased of the overall atelectasis proportions through the study follow-up, an improvement in cough capacity between the 7- and 14-day follow-up and a decrease in pain level. We also observed that the best concordance among cough capacity perception measures is between nurses and patients.

Our results are in accordance with the physiological phenomena that a decrease of pain can increase the ability to cough and decrease the risk of atelectasis (11-13).The large uncertainty regarding the association between cough capacity and atelectasis might be due to a lack of power, given that analyses were performed within strata of the presence of atelectasis at the initial visit. Several studies reported a moderate or good concordance among nurses and patients for the evaluation of different health questionnaires (23, 24). Our results are in concordance with the literature

While the QCM are quick and easy to use in medicine, the literature questions their validity since the answers given seem to be correlated to the level of prior knowledge(25).. Then QCM is an subjective evaluation and the gold standard to evaluate the cough capacity is the cough frequency assessment(26). This measure is often used in patients with neurodegenerative diseases, but they are time and resources consuming and are not practical in an emergency department setting. Moreover, one study showed a mild to moderate relationship between objective cough frequency and subjective measures of cough(27).It is therefore important to develop a valid, user-friendly and reliable patient questionnaire like Patient reported outcome measures (PROM) to evaluate the cough at the ED(28). PROMs allow patients to measure their functional well-being and health status. They are standardized and validated questionnaires. PROMs are recommended in the overall evaluation of the patient because they can help us understand if the services provided and the therapies really help the health and the quality of life of the patient(29, 30). Therefore, to increase the reproducibility of study evaluating cough capacity perception by the patient, PROM measures should be prioritized.

Limit and strength:

The association between cough capacity and atelectasis was a secondary analysis from a cohort study designed to build a clinical decision rule for delayed hemothorax after mTI (16). In addition, the measurement of atelectasis and coughing ability were done simultaneously, which may limit the interpretation of the association observed in this study.

In addition, losses to follow-up and missing data could have worsened the lack of power and introduced bias in the estimation of atelectasis proportions. However, using multiple imputations and IPCW may have helped mitigate those issues(17, 31).

Conclusion

There was not strong association between atelectasis and cough capacity, and a higher agreement between patients and nurse regarding cough capacity perceptions compared to physicians. Further studies could focus on developing a PROM questionnaire targeting patients with mTI as it is a common emergency department complaint, in order to improve medical management and patient quality of life.

References

1. Ho SW, Teng YH, Yang SF, Yeh HW, Wang YH, Chou MC, et al. Risk of pneumonia in patients with isolated minor rib fractures: a nationwide cohort study. BMJ Open. 2017;7(1):e013029.
2. Sanidas E, Kafetzakis A, Valassiadou K, Kassotakis G, Mihalakis J, Drositis J, et al. Management of simple thoracic injuries at a Level I trauma centre: can primary health care system take over? Injury. 2000;31(9):669-75.
3. Ziegler DW, Agarwal NN. The morbidity and mortality of rib fractures. J Trauma. 1994;37(6):975-9.
4. Witt C, Bulger E. Comprehensive approach to the management of the patient with multiple rib fractures: A review and introduction of a bundled rib fracture management protocol. Trauma Surgery & Acute Care Open. 2017;2:e000064.
5. Misthos P, Kakaris S, Sepsas E, Athanassiadi K, Skottis I. A prospective analysis of occult pneumothorax, delayed pneumothorax and delayed hemothorax after minor blunt thoracic trauma. Eur J Cardiothorac Surg. 2004;25(5):859-64.
6. Kerr-Valentic MA, Arthur M, Mullins RJ, Pearson TE, Mayberry JC. Rib fracture pain and disability: can we do better? J Trauma. 2003;54(6):1058-63; discussion 63-4.
7. Carver TW, Milia DJ, Somberg C, Brasel K, Paul J. Vital capacity helps predict pulmonary complications after rib fractures. J Trauma Acute Care Surg. 2015;79(3):413-6.
8. Little RA, Yates DW, Atkins RE, Bithell P, Stansfield M. The effects of minor and moderately severe accidental chest injuries on pulmonary function in man. Arch Emerg Med. 1984;1(1):29-38.
9. Erb J, Orr E, Mercer CD, Gilron I. Interactions between pulmonary performance and movement-evoked pain in the immediate postsurgical period: implications for perioperative research and treatment. Reg Anesth Pain Med. 2008;33(4):312-9.

10. Fernandez-Carmona A, Olivencia-Pena L, Yuste-Ossorio ME, Penas-Maldonado L. Ineffective cough and mechanical mucociliary clearance techniques. Med Intensiva. 2018;42(1):50-9.
11. Colucci DB, Fiore JF, Jr., Paisani DM, Risso TT, Colucci M, Chiavegato LD, et al. Cough impairment and risk of postoperative pulmonary complications after open upper abdominal surgery. Respir Care. 2015;60(5):673-8.
12. Fiore Jr J, Chiavegato L, Denehy L, Paisani D, Faresin S. Do Directed Cough Maneuvers Improve Cough Effectiveness in the Early Period After Open Heart Surgery? Effect of Thoracic Support and Maximal Inspiration on Cough Peak Expiratory Flow, Cough Expiratory Volume, and Thoracic Pain. Respiratory care. 2008;53:1027-34.
13. Postma K, Vlemmix LY, Haisma JA, de Groot S, Sluis TA, Stam HJ, et al. Longitudinal association between respiratory muscle strength and cough capacity in persons with spinal cord injury: An explorative analysis of data from a randomized controlled trial. J Rehabil Med. 2015;47(8):722-6.
14. Marini JJ. Acute Lobar Atelectasis. Chest. 2019;155(5):1049-58.
15. Hopkins E, Sharma S. Physiology, Functional Residual Capacity2019.
16. Emond M, Guimont C, Chauny JM, Daoust R, Bergeron E, Vanier L, et al. Clinical prediction rule for delayed hemothorax after minor thoracic injury: a multicentre derivation and validation study. CMAJ Open. 2017;5(2):E444-e53.
17. White I, Royston P, Wood A. Multiple imputation using chained equations: Issues and guidance for practice. Statistics in medicine. 2010;30(4).
18. Robins J, Rotnitzky AG, Zhao L. Analysis of Semiparametric Regression Models for Repeated Outcomes in the Presence of Missing Data. Journal of The American Statistical Association - J AMER STATIST ASSN. 1995;90:106-21.
19. Salazar A, Ojeda B, Dueñas M, Palacín F, Failde I. Simple generalized estimating equations (GEEs) and weighted generalized estimating equations (WGEEs) in longitudinal studies with dropouts: Guidelines and implementation in R. Statistics in medicine. 2016;35.
20. Ranganathan P, Pramesh CS, Aggarwal R. Common pitfalls in statistical analysis: Measures of agreement. Perspect Clin Res. 2017;8(4):187-91.
21. Sim J, Wright CC. The kappa statistic in reliability studies: use, interpretation, and sample size requirements. Phys Ther. 2005;85(3):257-68.
22. Marshall A, Altman DG, Holder RL, Royston P. Combining estimates of interest in prognostic modelling studies after multiple imputation: current practice and guidelines. BMC Med Res Methodol. 2009;9:57.
23. Kamdar BB, Shah PA, King LM, Kho ME, Zhou X, Colantuoni E, et al. Patient-nurse interrater reliability and agreement of the Richards-Campbell sleep questionnaire. Am J Crit Care. 2012;21(4):261-9.
24. Min A, Scott LD. Evaluating nursing hours per patient day as a nurse staffing measure. J Nurs Manag. 2016;24(4):439-48.

25. Ozuru Y, Briner S, Kurby CA, McNamara DS. Comparing comprehension measured by multiple-choice and open-ended questions. US: Educational Publishing Foundation; 2013. p. 215-27.
26. Spinou A, Birring SS. An update on measurement and monitoring of cough: what are the important study endpoints? J Thorac Dis. 2014;6(Suppl 7):S728-S34.
27. Birring SS, Matos S, Patel RB, Prudon B, Evans DH, Pavord ID. Cough frequency, cough sensitivity and health status in patients with chronic cough. Respir Med. 2006;100(6):1105-9.
28. Valentine JC, Pigott TD, Rothstein HRJJoE, Statistics B. How many studies do you need? A primer on statistical power for meta-analysis. 2010;35(2):215-47.
29. Columbia TUoB. Patient-Reported outcomes [cited 2020 April 22th]. Available from: https://patientreportedoutcomes.ca/what-are-pros/proms/.
30. Rotenstein LS, Huckman RS, Wagle NW. Making Patients and Doctors Happier — The Potential of Patient-Reported Outcomes. New England Journal of Medicine. 2017;377(14):1309-12.
31. Molenberghs G, Verbeke G. Models for Discrete Longitudinal Data. Springer, editor2005.

Tables

Table 1: Characteristics of study participants and lost to follow-up patients

Characteristic (%) of patients	*Participants N=1474*	*Patients losttofollow-up at 7 days N=213*	*Patients loss tofollow-up at 14 days N=341*
Demographic			
Age. Yr. mean	54.48	47.97	45.72
Sex. Male	61.44	66.20	66.28
Mechanism of injury			
Fall from height	35.14	38.03	34.60
Falling more than height	24.12	13.15	18.18
Motor vehicle crash	24.69	23.47	20.82
Others	16.05	25.35	26.39
Dyspnea			
Presence	22.51	15.02	17.60
Absence	73.31	72.30	73.02
No answer	4.18	12.68	9.38
Pain assessment			
Presence	53.18	48.36	53.08
Absence	46.72	51.17	46.92
Mean pain	7.16	7.10	6.94
COPD			
Presence	3.80	1.88	1.76
Absence	95.44	94.84	95.60
No answer	0.76	3.29	2.64
Asthma			
Presence	7.88	9.86	7.04
Absence	91.36	86.85	90.32
No answer	0.76	3.29	2.64
Smoking status			
Current smoker	25.26	27.70	26.39
Ex-smoker	21.27	16.43	15.25
No smoker	39.98	20.66	26.10
No answer	13.49	35.21	32.26

Table 2: *Relative proportions and 95% confidence interval (CI)between cough capacity and atelectasis a*djusted for age, sex, presence of dyspnea, tobacco.

Cough capacity	***Patients without atelectasis at initial visit (n=1343)***		***Patients with atelectasis at initial visit (n=131)***	
	7 days F/U	**14 days F/U**	**7 days F/U**	**14 days F/U**
Low/absent	2.89 (1.93 - 4.33)	1.26 (0.53 - 2.99)	1.09 (0.57 - 2.09)	1.24 (0.57 - 2.71)
Decreased	1.68 (1.20 -2.37)	1.34 (0.51 - 3.49)	0.76 (0.24 - 2.42)	1.34 (0.63 - 2.82)
Good/normal	1	1	1	1

Table 3: Proportion (CI 95%) of patient with low, decreased or good cough capacity according to nurses, physicians and patients at 7 and 14 day-follow-up.

	Patients without atelectasis at initial visit (n=1343)		*Patients with atelectasis at initial visit (n=131)*	
	7-days F/U	**14-days F/U**	**7-days F/U**	**14-days F/U**
Nurse				
w/absent (%)	8.54 (6.92 – 10.17)	5.30 (3.38 – 7.23)	13.05 (6.83 – 19.27)	10.27 (4.02 – 16.52)
ecreased (%)	42.78 (39. 90 – 45.64)	24.41 (21.62 – 27.21)	50.11 (40.88 – 59.33)	25.56 (17.23 – 33.89)
d/normal (%)	48.69 (45.79 – 51.59)	70.28 (66.87 – 73.69)	36.84 (27.94 – 45.75)	64.17 (54.38 – 73.96)
ysicians				
w/absent (%)	11.71 (9.83 – 13.58)	9.14 (7.65 – 11.22)	15.99 (9.23 – 22.76)	10.55 (4.27 – 16.83)
ecreased (%)	31.52 (28.83 – 34.21)	16.53 (14.20 – 18.86)	37.65 (28.71 – 46.59)	21.40 (13.49 – 28.79)
d/normal (%)	56.77 (53.90 – 59.65)	74.33 (71.38 – 77.28)	46.36 (37.16 – 55.56)	68.31 (59.26 – 77.36)
atients				
w/absent (%)	16.05 (13.92 – 18.19)	12.80 (9.66 – 15.95)	20.14 (12.74 – 27.54)	14.41 (6.59 – 22.22)
ecreased (%)	48.87 (45.97 – 51.77)	33.80 (30.02 – 37.58)	52.07 (42.85 – 61.28)	33.46 (24.40 – 42.52)
d/normal (%)	35.07 (32.31 – 37.84)	53.39 (50.07 – 56.72)	27.79 (19.53 – 36.05)	52.14 (42.06 – 62.21)

Table 4Mean (95% CI)of the pain assessment among patients at initial visit and follow-up

	Patients without atelectasis at initial visit (n=1343/1474)			*Patients with atelectasis at initial visit (n=131/1474)*		
tients	Initial visit	7 days	14-day	Initial visit	7 days	14-day
/ ent	7.38 (6.83-7.93)	4.05 (3.53-4.56)	3.18 (2.73-3.63)	6.96 (5.42-8.51)	4.51 (3.08-5.94)	3.15 (1.84 -4.45)
reased	7.51 (7.21 -7.81)	4.69 (4.36 -5.02)	3.98 (3.68 -4.29)	7.97(7.22 - 8.72)	4.58 (3.62-5.53)	3.94 (3.15-4.74)
d/ nal	6.72 (6.50 - 6.95)	3.70 (3.40 - 4.00)	2.63 (2.46 - 2.81)	6.99 (6.38 - 7.60)	3.87 (3.20-4.54)	2.67 (2.21-3.14)

Table 5: Weighted kappa (95% CI) of the agreement between cough capacity perception measured by nurses, physicians and self-assessed.

	Patients without atelectasis at initial visit (n=1343)		*Patients with atelectasis at initial visit (n=131)*	
	Nurse	**Physician**	**Nurse**	**Physician**
Patient				
7 days	0.55 (0.51 - 0.59)	0.33 (0.29 - 0.37)	0.65 (0.52 - 0.78)	0.39 (0.26 - 0.51)
F/U	0.52 (0.44 - 0.59)	0.33 (0.27 - 0.39)	0.54 (0.37 - 0.71)	0.42 (0.24 - 0.59)
14 days				
f/U				