

The Hanging Chin Sign As A Mortality Predictor In Geriatric Patients At The Emergency Department: A Retrospective Cohort Study

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Abstract

BACKGROUND: At the emergency department, there is a need for an instrument which is quick and easy to use to identify geriatric patients with the highest risk of mortality. The so-called 'hanging chin sign', meaning that the mandibula is seen to project over one or more ribs on the chest X-ray, could be such an instrument. This study aims to investigate whether the hanging chin sign is a predictor of mortality in geriatric patients admitted through the emergency department.

METHODS: We performed an observational retrospective cohort study in a Dutch teaching hospital. Patients of \geq 65 years who were admitted to the geriatric ward following an emergency department visit were included. The primary outcome of this study was mortality. Secondary outcomes included the length of admission, discharge destination and the reliability compared to patient-related variables and the APOP screener.

RESULTS: 396 patients were included in the analysis. Mean follow up was 300 days; 207 patients (52%) died during follow up. The hanging chin sign was present in 85 patients (21%). Patients with the hanging chin sign have a significantly higher mortality risk during admission (OR 2.94 (1.61 to 5.39), $p < 0.001$), within 30 days (OR 2.49 (1.44 to 4.31), $p = 0.001$), within 90 days (OR 2.16 (1.31 to 3.56), $p = 0.002$) and within end of follow up (OR 2.87 (1.70 to 4.84), $p < 0.001$). A chest X-ray without a PA view or lateral view was also associated with mortality. This technical detail of the chest x-ray and the hanging chin sign both showed a stronger association with mortality than patient-related variables or the APOP screener.

CONCLUSIONS: The hanging chin sign and other details of the chest x-ray were strong predictors of mortality in geriatric patients presenting at the emergency department. Compared to other known predictors, they seem to do even better in predicting mortality.

Introduction

Worldwide, the number of older adults (aged 65 and over) presenting at the emergency department (ED) is increasing, particularly due to their growing proportion in the population.^{1,2,3} During 2014–2017, 20% of all emergency department visits in the United States were made by patients aged 60 years and older, which corresponds to 29 million ED visits each year. Nearly one-quarter (23%) of ED visits among patients aged 60 and over resulted in a hospital admission.⁴ Acute medical illness in hospitalised older adults is associated with functional decline and mortality during and after hospitalisation.^{5,6,7} Within one year of acute admission at the geriatric ward, mortality rates are high, ranging from 17.2 to 40.2 worldwide.⁸

There are several tools which predict mortality in the general population, but their value for the geriatric patient at the ED is still unclear. Risk assessment instruments for risk stratification of older adults following ED care do exist. However, Carpenter et al⁹ showed in a large systematic review and meta-analysis that none of the published risk stratification instruments (including ISAR, ISAR modifications, TRST and VIP) demonstrate sufficient prognostic accuracy to distinguish high-risk or low-risk subsets of geriatric patients in EDs. The authors demonstrated the same lack of prognostic accuracy for individual predictors of vulnerability and validated measurements of frailty. Recently, a screening tool for acute presenting older patients (APOP) was introduced that predicts adverse health outcomes for older ED patients. The investigators developed and validated prediction models for a 90-day composite outcome and a 90-day mortality in older emergency patients.^{10,11} Presumably this is the best predictor of mortality in geriatric patients. Unfortunately, it is still a time-consuming tool.

Nonetheless, it is important to estimate the prognosis for the geriatric patient. Identification of those at highest risk presents the opportunity to offer the correct intensity of care and to guide preventive interventions and informed decisions about treatment.¹² Therefore, there is a need for a quick and easy-to-use tool to predict mortality in the geriatric patient.

In clinical practice, there is a subjective feeling that the ‘hanging chin sign’ is related to a worse outcome. This sign can be observed on the chest X-ray, and is present when the mandibular bone is projected over one or more ribs. It is an objective sign which is easy to interpret. Van Beijnen et al recently showed that critically ill patients consulted by an intensive care unit (ICU) physician at the ED and displaying a hanging chin have higher in-hospital mortality.¹³ But further evidence is lacking, especially for the geriatric patient admitted at the general geriatric ward following the ED visit.

This study aims to assess whether sign of a hanging chin is a predictor of mortality in geriatric patients admitted through the ED. Secondly, the study aims to investigate if technical details related to the X-ray (e.g. presence of posteroanterior (PA), anteroposterior (AP) or lateral view) are also predictors of mortality. Other secondary objectives are to assess the association between the hanging chin sign, the length of hospital admission and the destination of discharge, and to compare the hanging chin sign with the APOP screening tool.

Methods

Study design & participants

A single-centre, observational retrospective cohort study was performed in a large teaching hospital in the Netherlands. Data were extracted from the electronic health record and were part of standard care. Patients who were admitted to the geriatric ward following an ED visit between January 1, 2018 and December 31, 2018 were included. Additional inclusion criteria were: being aged 65 years or older and having had a chest X-ray performed at admission. The first admission was selected when patients were admitted more than once during the enrolment period. Exclusion criteria were:

- hip fracture as admission diagnosis, because although these patients were admitted to the orthopedic ward and their condition, hospitalisation and prognosis take a different course.
- outlying patients, which means that the patient was admitted to be seen by the geriatrician but stayed on another ward, and therefore did not receive standard geriatric care
- transfers from other hospitals, because these patients were seen at a later stage in course of their illness

The follow-up ended on November 5, 2019.

Automatic data extraction using CTcue

Patients were selected using CTcue, an application which structures and collects data from the electronic health record system and is widely used in Dutch and Belgium hospitals.¹⁴ All patients with an age ≥ 65 and admitted to the geriatric ward during the study period were extracted. All extracted patients were then manually verified in the electronic health record, using inclusion and exclusion criteria. Doubles were checked. Age, sex, admission and discharge dates were obtained from CTcue, other data was obtained from chart review. The collected data were standard elements of the comprehensive geriatric assessment performed on every patient admitted through the

ED. The data were collected using a system with predefined criteria for classifying recorded data. Patients and families were not approached for any additional data.

Patient characteristics

Patient characteristics were selected based on previous research.^{9,10} Patient characteristics were divided in general characteristics, estimation of severity of disease and geriatric features.

First, general patient characteristics were collected: age, sex, admission and discharge dates and admission diagnosis. In some patients there were multiple admission diagnoses; in these cases, we selected the one that was mentioned first in the conclusion of the admission letter.

Second, patient characteristics related to the estimation of severity of disease and geriatric features were collected: mode of transportation to the ED, living independently (including sheltered home or living with relatives) or institutionalised, number of medications at admission (where a fixed dose combination was counted as 1), polypharmacy (≥ 5 medicine prescribed), help needed during bathing/showering and dressing, help needed during daily activities, previous hospital admission in the past six months, fall-related ED visit, the need for laboratory testing, presence of diagnosis of 'dementia' and the two questions 'in which year do we live?' and 'in which month do we live?' to assess orientation in time.

Chest X-ray

All chest X-rays were retrospectively reviewed. The following details were documented: presence of the hanging chin sign, patient position of acquisition (standing, sitting or lying), projection view (Posteroanterior (PA) or anteroposterior (AP)) and presence of a lateral view. In case of doubt, an independent blinded radiologist (LB) was consulted. Disagreement was resolved by consensus between the researcher AH and radiologist LB.

Figure 1 shows the different projection views of the chest X-ray (1A-C). Preferably, a chest X-ray consists of a standing PA view and lateral view. When a patient is unable to stand, an AP view is acquired in sitting or even lying position. An AP view is non-preferable because of lower quality and magnification of the heart, making it more difficult to evaluate.¹⁵

The hanging chin sign is most commonly seen on a chest X-ray made in AP view (Fig. 1D). The hanging chin is also seen in PA view, but to a lesser extent, especially in patients with lordosis or (hyper)kyphosis (Fig. 1E-F). Neuromuscular disorders are also mentioned as a cause.¹⁶

Hanging chin sign

The 'hanging chin sign' on the chest X-ray was considered positive when the mandibular bone was projected over one or more ribs (Fig. 2).¹⁴ Patients were excluded when the chest X-ray was incomplete or was of poor quality.

Primary outcome measures

Primary outcome was mortality during admission, within 30 days, within 90 days and at the end of follow up. Mortality was obtained from the electronic health record and double-checked in the national mortality registry.

Secondary outcome measures

Details of the chest X-ray were obtained from the electronic health record. Projection view (posteroanterior (PA) or anteroposterior (AP)) and patient position of acquisition (standing, sitting or lying) were displayed on the chest X-

ray itself or included in the report.

The discharge destination was obtained from the electronic health record. The different discharge destinations were divided into four categories: 1. Home, sheltered home or living with children, 2. Nursing home or psychiatric institution, 3. Geriatric revalidation care and 4. Hospice or terminal care. We compared the residency before admission with the discharge destination and reported whether there was any change after admission. The admission length was calculated using the dates of admission and discharge.

According to the formula of the APOP study, a 90-day mortality risk was calculated.⁸ Subsequently, patients were divided into high- and low-risk groups as in the APOP study, defining the high-risk group as the 20% of patients with the highest risk of the outcome.

Data analysis

Data were transferred to the Statistical Package for Social Sciences (SPSS, IBM) version 22 for analysis.

Outcomes between patients with and without a hanging chin sign were compared using the χ^2 test and logistic regression, calculating Odds ratios and Kaplan-Meier curves. Sensitivity, specificity, positive likelihood ratio and negative likelihood ratio were calculated. The same was done for the other aspects of the chest X-ray.

Patient-related variables (age, number of medications, polypharmacy, way of living, arrival by ambulance, help needed with bathing/dressing, fall related visit) and outcomes of the APOP screening tool were analysed for prediction of mortality by using the χ^2 test or logistic regression and calculating Odds ratios. Analysing non-inferiority of predicting mortality by the 'hanging chin sign' compared to the APOP screening tool was not possible, as both use different data types.

Length of hospital stay was tested for normality by Kolmogorov-Smirnov and Shapiro-Wilk tests. Outcomes were compared using the Mann-Whitney test. Discharge location and change in discharge destination were analysed using the χ^2 test.

A sample size calculation was not performed, due to the lack of incidence rates in the literature. We assumed that a sample of this size should be sufficient to demonstrate whether the 'hanging chin sign' is a suitable predictor of mortality or not.

Results

Patient selection

As shown in Fig. 3, CTcue extracted 670 patients. After manual verification, 439 patients met the inclusion criteria.

Data extraction was performed for these 439 patients. By doing this, 42 patients were excluded because of poor quality of the chest X-ray which meant that we were unable to identify the first rib, and one patient was excluded because they were lost to follow up, due to absence of registration in the Dutch basic register. Therefore, 396 patients of 439 patients (90.2%) who met the inclusion criteria were included in the analysis. There were no missing data, except for orientation in time and year (both available in only 215 patients) and for patient position of the AP view (available in only 264 patients).

Patient characteristics

A total of 396 patients were included. As shown in Table 1, the mean age of the total study population was 85.1 years (standard deviation (SD) 6.4 years; range 65–101 years). Of the patients, 224 (57%) were female. The mean follow-up was 300 days (SD 220 days), with a maximum of 672 days. At the end of the follow-up, 207 patients (52%) had died. The hanging chin sign was present in 85 patients (21%). Patients with evidence of the hanging chin sign were significantly more likely to live in residential care or a nursing home ($p = 0.001$), arrived more often by ambulance ($p = 0.001$) and needed more help with bathing or dressing ($p = 0.011$), compared with patients without the hanging chin sign. Other characteristics were not significantly different between the two groups.

Table 1. Patients characteristics

Characteristics	All patients n = 311	No hanging chin sign (n = 85)	Hanging chin sign (n = 85)	Statistics
Demographics				
Age	85.1 (SD 6.7)	85.0 (SD 6.7)	85.3 (SD 6.7)	p = 0.984
Female	224 (56.6%)	176 (56.6%)	48 (56.5%)	p = 0.984
Living in residential care or nursing home	81 (20.5%)	53 (17.0%)	28 (32.9%)	p = 0.001
Severity of disease indicators				
Arrival by ambulance	302 (76.3%)	226 (72.7%)	76 (89.4%)	p = 0.001
Fall-related ED visit	92 (23.2%)	73 (23.5%)	19 (22.4%)	p = 0.828
Diagnosis at admission				
* Infectious disease	230 (58.1%)	176 (56.6%)	54 (63.5%)	
* Heart disease	23 (5.8%)	18 (5.8%)	5 (5.9%)	
* Delirium	42 (10.6%)	31 (10.0%)	11 (12.9%)	
* Falling/mobility disorder	47 (11.9%)	40 (12.9%)	7 (8.2%)	
* Other	54 (13.6%)	46 (14.8%)	8 (9.4%)	
Indication for laboratory testing	396 (100%)	311 (100%)	85 (100%)	-
Geriatric measurements				
Hospital admission in past six months	81 (20.5%)	65 (20.9%)	16 (18.8%)	p = 0.674
Number of different medications	8.6 (SD 4.3)	8.2 (SD 4.1)	10.0 (SD 4.6)	p = 0.125
Help needed with bathing/dressing	277 (69.9%)	208 (66.9%)	69 (81.2%)	p = 0.011
Help needed with daily activities	359 (90.7%)	279 (89.7%)	79 (92.9%)	p = 0.077
Disorientated in year (N = 215)	125 (58.1%)	100 (59.2%)	25 (54.3%)	p = 0.557
Disorientated in month (N = 215)	109 (50.7%)	88 (52.1%)	21 (45.7%)	p = 0.440
History of dementia	144	109 (35.0%)	35 (41.2%)	p = 0.298

Primary outcome

Table 2 shows that patients with the hanging chin sign have a significantly greater risk of dying during admission (OR 2.942 (1.607–5.386), $p < 0.001$), within 30 days (OR 2.489 (1.437–4.311), $p = 0.001$), within 90 days (OR 2.158 (1.308–3.558), $p = 0.002$) and within the end of follow-up (OR 2.872 (1.704–4.842), $p < 0.001$).

Sensitivity, specificity, positive likelihood ratio and negative likelihood ratio of the hanging chin sign for death during admission, within 30 days, within 90 days and at the end of follow-up are shown in Table 3. Positive likelihood ratios range from 1.80 to 2.32, negative likelihood ratios from 0.74 to 0.83.

Figure 4 shows the Kaplan-Meier survival curves for the length of time after admission until death or end of follow-up. There was a significant difference in survival time between patients with the hanging chin sign and patients without the hanging chin sign ($p < 0.001$) (Fig. 4A). The mean survival in patients with hanging chin sign was 199 days (e.g. 6.6 months) vs. 383 days (e.g. 12.8 months) in patients without hanging chin sign.

Table 2. Variables that can predict mortality

	Death during admission	30-day mortality		90-day mortality		Death (mean follow up 300 days)		
Chest X-ray	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	p	OR (95% CI)	p
Hanging chin sign	2.94 (1.61 – 5.39)	<0.001	2.49 (1.44 – 4.31)	0.001	2.16 (1.31 – 3.56)	0.002	2.87 (1.70 – 4.84)	<0.001
AP-view instead of PA-view	4.33 (1.68 – 11.17)	0.001	3.34 (1.60- 6.96)	0.001	2.17 (1.26- 3.73)	0.005	1.62 (1.04 – 2.53)	0.033
Lateral view absent	2.31 (1.28 – 4.17)	0.005	1.87 (1.10 – 3.19)	0.020	1.92 (1.19 – 3.08)	0.007	1.28 (0.81 – 2.00)	0.289
Patient related variables	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
Age	1.04 (0.99 – 1.08)	0.119	1.03 (0.99 – 1.07)	0.147	1.05 (1.01 – 1.09)	0.006	OR 1.05 (1.01 – 1.08)	0.004
Number of medications	1.05 (0.99 – 1.13)	0.117	1.06 (1.00 – 1.13)	0.039	1.05 (0.99 – 1.10)	0.076	1.08 (1.03 – 1.13)	0.002
Polypharmacy	0.59 (0.30 – 1.15)	0.117	1.07 (0.55 – 2.08)	0.835	1.05 (0.60 – 1.86)	0.858	1.33 (0.79 -2.22)	0.281
Living institutionalised	1.10 (0.51 – 2.20)	0.787	1.52 (0.85 – 2.71)	0.159	1.29 (0.76 – 2.18)	0.340	1.85 (1.12 – 3.07)	0.016
Arrival by ambulance	1.47 (0.71 – 3.05)	0.297	1.48 (0.78 – 2.78)	0.226	1.26 (0.74 – 2.13)	0.391	1.07 (0.67 – 1.69)	0.788
Help needed with bathing/dressing	1.46 (0.75 – 2.83)	0.264	1.62 (0.90 – 2.93)	0.104	2.08 (1.24 – 3.49)	0.005	2.20 (1.42 – 3.42)	<0.001
Fall-related	1.15	0.674	1.13	0.685	0.95	0.851	0.89	0.618

emergency department visit	(0.60 – 2.22)		(0.63 – 2.02)		(0.57 – 1.60)		(0.56 – 1.42)	
APOP score	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
APOP 90-day mortality risk (%)	1.01 (0.99 – 1.02)	0.245	1.01 (1.00 – 1.03)	0.049	1.02 (1.01 – 1.03)	0.002	1.03 (1.01 – 1.04)	<0.001
APOP 90-day high vs low risk	1.19 (0.59 – 2.37)	0.632	1.25 (0.68 – 2.29)	0.474	1.52 (0.90 – 2.58)	0.115	1.91 (1.14 – 3.20)	0.013

Abbreviations: OR, odds ratio; CI, confidence interval; AP, anteroposterior; PA, posteroanterior; APOP score, acute presenting older patients score⁸.

Table 3. Sensitivity, specificity, positive likelihood ratio and negative likelihood ratio of the hanging chin sign

Hanging chin sign	Sensitivity, %	Specificity, %	Positive LR	Negative LR
during admission	40.0	81.5	2.16	0.74
within 30 days	35.5	81.9	1.96	0.79
within 90 days	31.3	82.6	1.80	0.83
at the end of follow up (mean 300days)	29.5	87.3	2.32	0.81

Abbreviations: LR = likelihood ratio

Secondary outcomes

Table 2 shows the variables that were tested for their ability to predict mortality: aspects of chest X-ray, patients related variables and the APOP score. The different aspects of the chest X-ray are also significant individual predictors of death during admission, 30-day mortality, 90-day mortality and death at the end of follow-up (mean 300 days). Patient-related variables are mostly unable to predict mortality, especially when it comes to death during admission and 30-day mortality. As shown in table 2, the strongest predictor appeared to be the hanging chin sign.

Figures 4B shows that there was a significant difference in survival time between patients with AP view and PA view, in favour of the PA view (log rank test p = 0.012). The presence of a lateral view seems to predict a better 30-day and 90-day survival, but was not significant in the long term (Figure 4C).

The APOP score was also capable of predicting mortality, except for death during admission. The cut-off point for the high-risk group in our study was a APOP risk score of 44.3%. As shown in table 3, high risk according to the APOP score was not a predictor of death during admission (p=0.632), 30-day mortality (p=0.474) and 90-day mortality (p=0.115), but it was of death till the end of follow-up (p=0.013). Figure 4D shows the Kaplan-Meier plots of APOP high vs. low risk.

Length of admission was not significantly different ($p = 0.852$) between patients with the hanging chin sign (mean 12.1 days, SD 15.6 days) and patients without the hanging chin sign (mean 10.3 days, SD 10.9 days). After exclusion of patients who died during admission, length of admission was still not significantly different ($p = 0.239$).

Table 4 shows the discharge destination of the 341 patients (86%) who survived hospital admission. Although patients with the hanging chin sign were more likely to go to a nursing home or psychiatric institution, there was no significant difference ($p = 0.239$) in discharge destinations between patients with and without hanging chin sign. Furthermore, there was no significant difference regarding change in discharge destination between patients with and without hanging chin sign (OR 1.047 (CI = 0.543 - 2.018), $p = 0.892$) resp. 22.2% (14/63) and 23% (64/278) of the patients were not able to go to their previous living place and needed more intensive or terminal care.

Table 4. Discharge destination

	Discharge destination				Total
	home/sheltered/ with children	nursing home/ psychiatric institution	geriatric revalidation care	hospice/ terminal care	
No hanging chin sign	171 (61.5%)	85 (30.6%)	14 (5.0%)	8 (2.9%)	278 (100%)
Hanging chin sign	30 (47.6%)	26 (41.3%)	4 (6.3%)	3 (4.8%)	63 (100%)
Total	201 (58.9%)	111 (32.6%)	18 (5.3%)	11 (3.2%)	341 (100%)

Discussion

This study shows that the hanging chin sign is a predictor of mortality in geriatric patients admitted through the ED, in both the short and long term. This confirms our hypothesis that the hanging chin sign in geriatric patients is associated with a poor prognosis. In our study, this predictor is a stronger predictor than known predictors such as age, help needed with bathing/dressing (e.g. activities of daily living) and APOP. Predictive performance of the hanging chin sign was also compared with the predictive performance of other screening instruments, as reported by Carpenter et al: positive and negative likelihood ratios of the hanging chin sign appeared to be better than those of the ISAR, TRST and other (frailty) screening instruments.⁹ Other predictors of mortality deriving from the chest X-ray were the presence of an AP view (instead of a PA view) and the absence of a lateral view. Both the hanging chin sign and other chest X-ray features are objective and easily available markers, which makes the chest X-ray a quick and easy-to-use tool to predict mortality in the geriatric patient.

This study is the first to investigate whether the hanging chin sign is a predictor of mortality in geriatric patients admitted to the geriatric ward. Although the hanging chin sign is something which is often referred to in Dutch hospitals, Van Beijnen et al. were the first and only ones to describe this sign.¹¹ They showed that critically ill adult patients presenting at the ED with the hanging chin sign have a higher in-hospital mortality risk. Our study showed that the hanging chin sign is also applicable to the geriatric patient presenting at the ED, and is also useful for

predicting 30-day, 90-day and 300-day mortality. We found no association with change in discharge destination or length of admission, nor did Van Beijnen et al. for length of admission.

There are some limitations to this study. First, we performed a retrospective study using data from the electronic health record. This makes it difficult to recall missing data and interpret some results. The chart abstractor was not blinded for the study hypothesis. We tried to minimise the effect of this by using clear predefined criteria, leaving very little interpretation. Furthermore, a blinded radiologist was consulted when there was doubt about the presence of the hanging chin sign.

Second, 42 patients (9.6%) were excluded because of the poor quality of the chest X-ray. This might have caused selection bias and spectrum bias, which might have increased sensitivity and specificity. But for comparison, Van Beijnen et al¹¹ excluded 26% of patients for this reason.

Third, baseline characteristics did differ slightly between the two groups. This suggests that the patients with the hanging chin sign were slightly more frail and ill at baseline than patients without the hanging chin sign. However, we believe that is a logical consequence: the presence of the hanging chin sign is a reflector of severity of frailty and illness. Correcting for this would devalue the hanging chin sign because it removes the cause of the sign. Therefore, multivariate logistic and linear regression analysis was not performed either. We believe that the hanging chin sign incorporates all the other factors. Nonetheless, the 90-day mortality risk according to the APOP study, a prediction model which included multiple factors, was calculated. In our study, the hanging chin sign appeared to be non-inferior, possibly even better, than the APOP 90-day mortality risk, based on the odds ratios and Kaplan-Meier survival curve. Positive and negative likelihood ratios were compared with previous research, using the outcomes of the study of Gelder et al, both favouring the APOP screener: the positive likelihood ratios of the hanging chin sign ranging from 1.80-2.32 versus 2.53-5.50 for the APOP 90-day mortality risk (according to different thresholds), and negative likelihood ratios of the hanging chin sign ranging from 0.73-0.84 versus 0.46-0.67 for the APOP 90-day mortality risk (according to different thresholds).¹⁰ Nevertheless, the hanging chin sign is less time consuming than the APOP screener.

Finally, in this study the 90-day mortality risk according to the APOP study was used. However, the APOP study group only validated the 90-day composite outcome for all the older patients at the ED. Furthermore, the 90-day mortality risk formula was composed to calculate a 90-day mortality risk, not death during admission, 30-day mortality or 300-day mortality. But remarkably, the odds ratio for 90-day mortality was not significant when calculated for patients with a high- and low-risk APOP score. The cut-off point for high vs. low risk in our study was comparable to the cut-off point of the APOP study itself, suggesting that the study population of both trials were comparable.

The hanging chin sign is an expression of inability to keep the head up, due to general weakness caused by illness or frailty.¹¹ As mentioned before, the hanging chin is also seen in patients with lordosis or kyphosis or neuromuscular disorders.¹³ Since it was hard to find out whether a patient was known to have one of these conditions, in the absence of a complete medical history, it was difficult to differentiate. However, different studies have shown that kyphosis is also associated with a poor prognosis^{17,18,19}. This could make the differentiation less relevant.

The absence of a PA view (and thus presence of AP view) suggests that it was not possible to make a standing chest X-ray. The absence of a lateral view suggests that it was not possible to stand or to sit straight and raise the

arms. This is probably an expression of general weakness caused by illness with or without frailty, as it is unlikely that there were technical or time-related issues. Our findings suggest that the above-mentioned features of chest X-ray are able to identify the patients with severe illness and/or frailty and thus poor prognosis.

The results of our study suggest that the standard chest X-ray contains more information than one might think. The chest X-ray gives easily interpretable information of mortality in an early stage. It could help identify those at risk of mortality, which might allow optimizing therapy for each patient.

Conclusions

In conclusion, in this study, the hanging chin was a rather strong predictor of mortality in geriatric patients presenting at the ED. Other hidden features of the chest X-ray (absence of PA view and/or lateral view) were also predictors of mortality in these patients. Compared to other patient related variables, they seem to do even better in predicting mortality. The chest X-ray is widely available and contains useful and easy-to-interpret information that can be used for identifying those with a poor prognosis. Future research should be of prospective design and focus on predicting functional decline as well.

Abbreviations

ED Emergency department

ISAR Identifications of seniors at risk (screening tool)

TRST Triage risk screening tool

VIP Variable Indicative of Placement risk (screening tool)

APOP Acute presenting older patients (screening tool)

ICU Intensive care Unit

PA Posteroanterior

AP Anteroposterior

SPSS Statistical Package for Social Sciences

WMO Law on Medical Research (*Wet medisch-wetenschappelijk onderzoek*)

WGBO Medical Treatment Contracts Act (*Wet op de geneeskundige behandelingsovereenkomst*)

SD Standard deviation

OR Odds ratio

CI Confidence interval

Resp. Respectively

Declarations

Ethics approval and consent to participate

The regional ethical review board (METC Brabant/18.238, #NW2018-37) declared that this study falls outside the scope of the Dutch Law on Medical Research (WMO) and approved the study design. Informed consent was not asked from the participants, accordance to the Dutch Medical Treatment Contracts Act (WGBO), article 458. Because of the high number of participants included, taking informed consent was considered not reasonably possible and above that selection bias could be included by taking informed consent as undesirable side effect. However, patients who had previously objected to their information being used for scientific research, by the hospital opt-out procedure, were excluded. We used already existing data and patients and families were not approached for any additional data. The physical and psychological integrity of the patients were intact during this research and were not harmed in any way. The study is carried out according to the principles of the WMA Declaration of Helsinki; 2013.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request

Competing interests

The authors declare that they have no competing interests

Funding

None

Authors' contributions

AH and CK defined the study concept and design. AH collected, analyzed and interpreted the patient data. CK was a major contributor in interpreting data. LB analyzed the X-rays when requested and assisted with formatting graphics. All authors contributed to the preparation of the manuscript. All authors approved the final manuscript.

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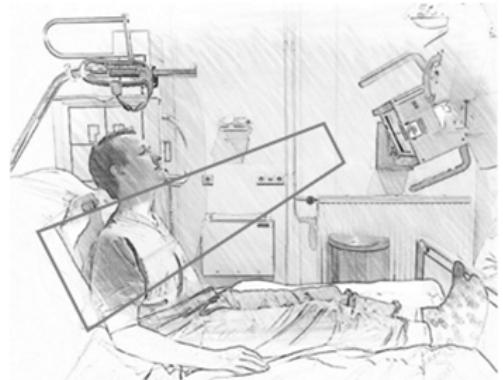
Figures



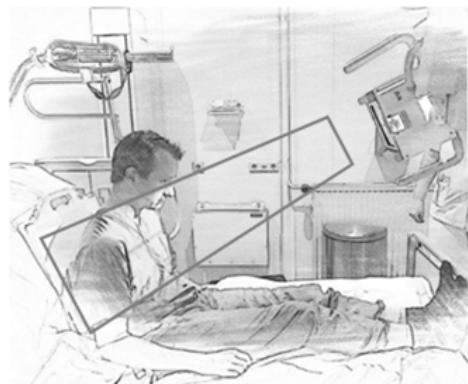
A. Posteroanterior (PA) view



B. Lateral view



C. Anteroposterior (AP) view



D. AP view with hanging chin



E. PA view with lordosis



F. PA view with kyphosis

Figure 1

Projection views of chest X-ray (Figure by author) Figures A and B show the standard projections of the chest X-ray. The patient is standing against the detector. Figure C shows an AP projection without the presence of a

hanging chin sign. Figures D, E and F show examples in which a hanging chin sign could be seen on the chest X-ray.

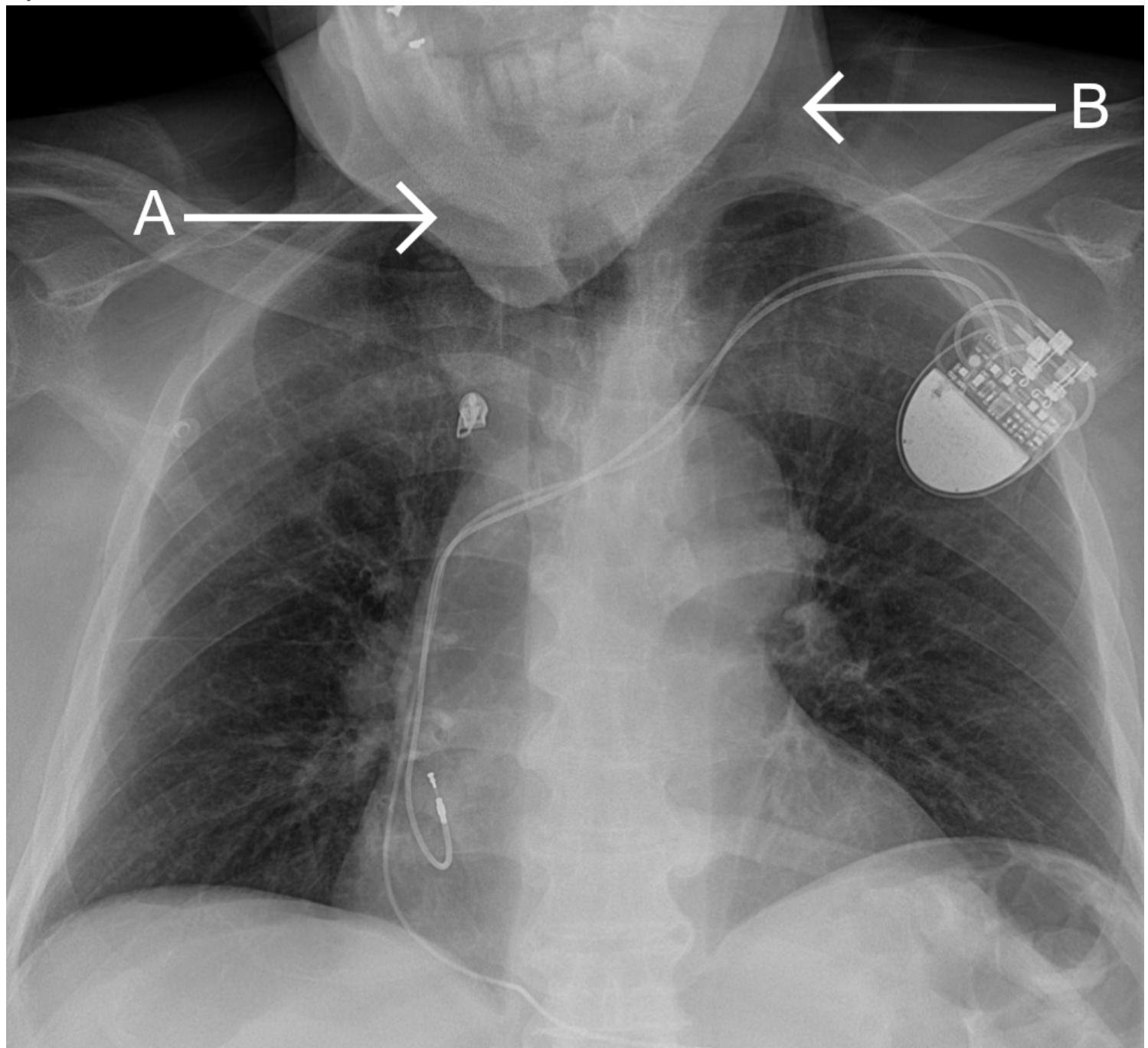


Figure 2

Hanging chin sign: mandibular bone (A) projected over the first rib (B)

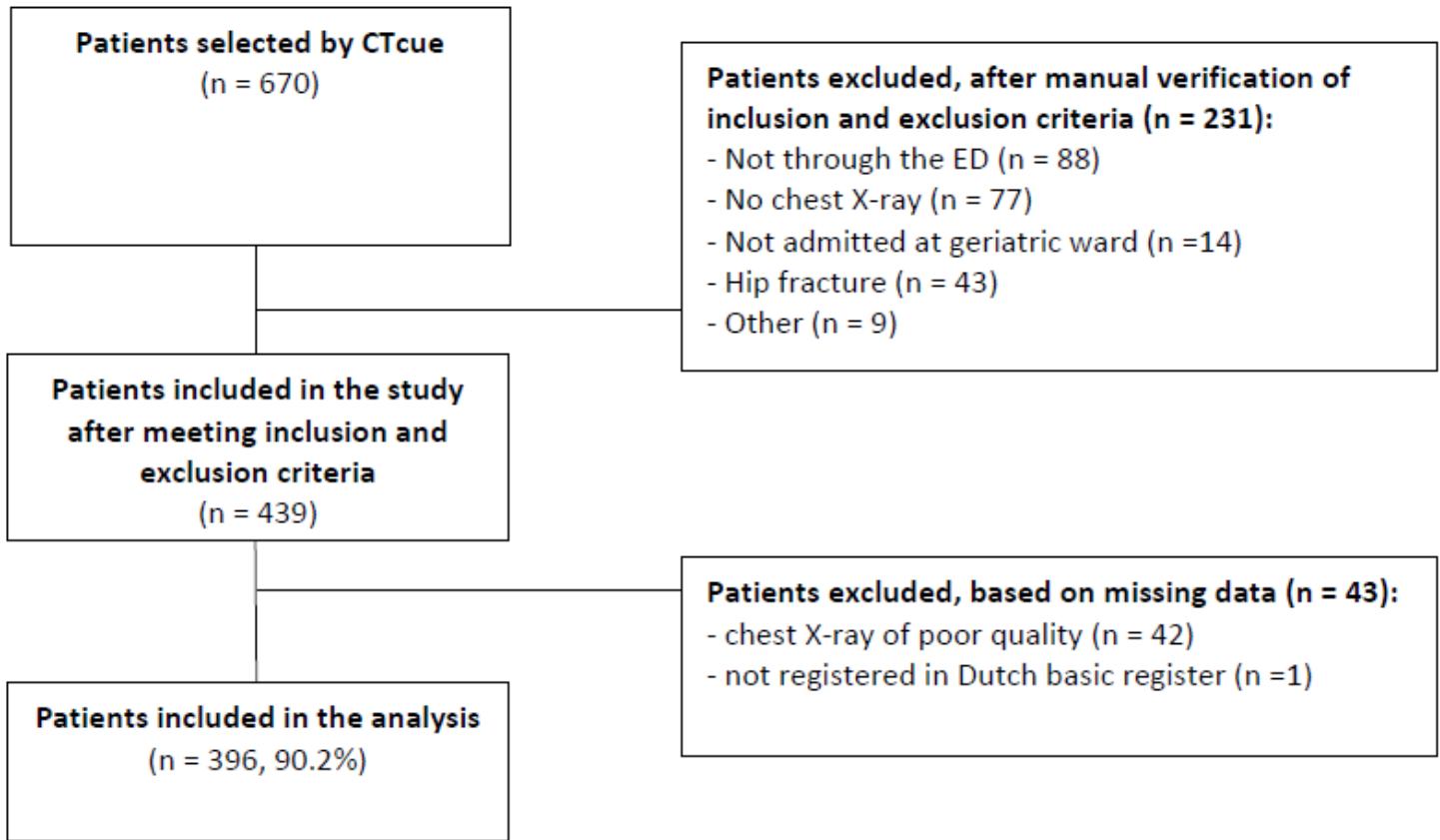


Figure 3

Flow diagram of patient selection Abbreviation: ED, emergency department.

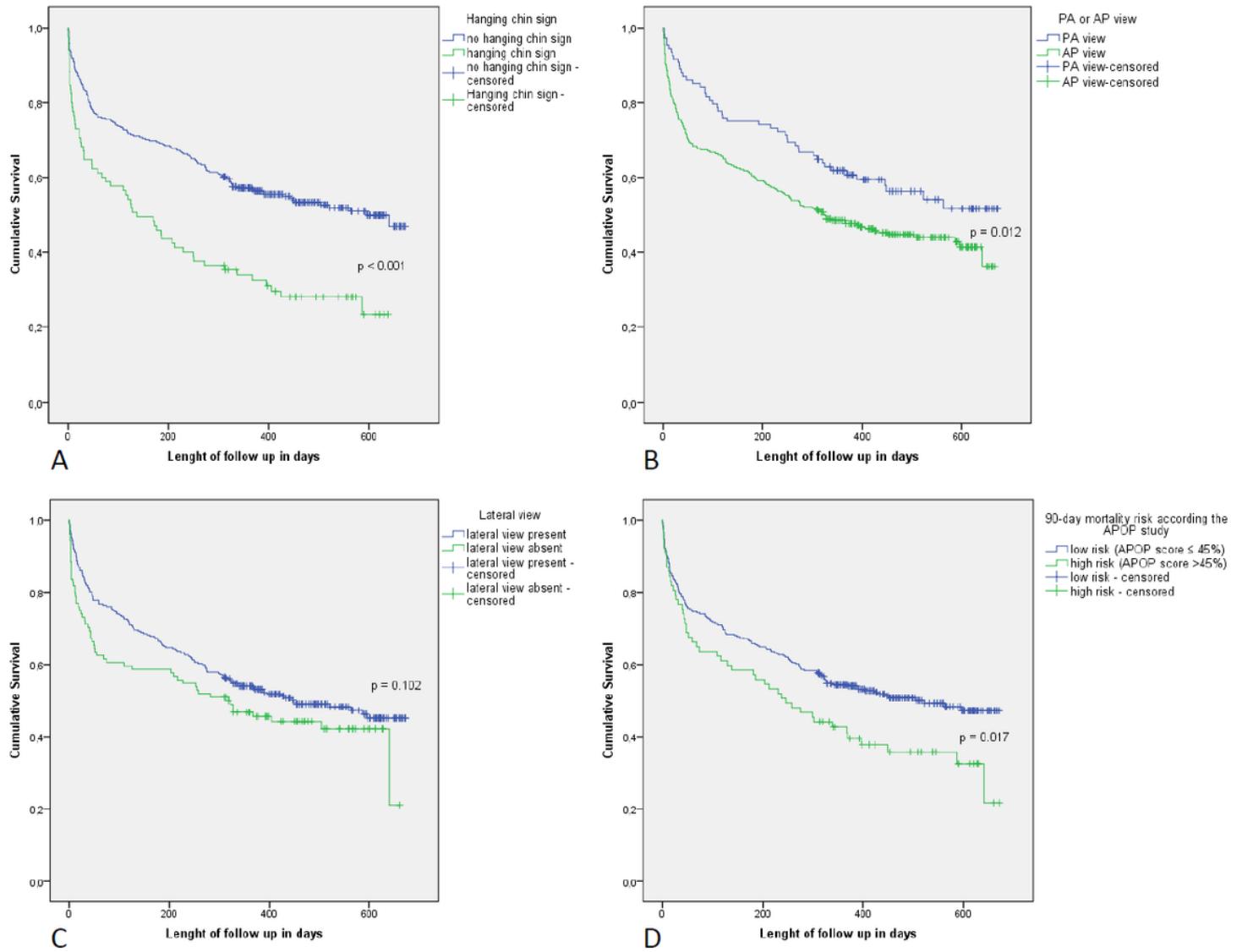


Figure 4

Kaplan-Meier plot of estimated survival in patients with A. Hanging chin sign vs. no hanging chin sign, B. PA-view vs. AP-view, C. Lateral view present vs. lateral view absent, D. 90-day mortality risk according the APOP study, high risk vs. low risk. Abbreviations: PA, posteroanterior; AP, anteroposterior; APOP, acute presenting older patient⁸