Diagnostic anticipation to reduce emergency department length of stay: a cohort study in Ferrara University Hospital, Italy

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Abstract

Background : Emergency Department (ED) crowding reduces staff satisfaction and healthcare quality and safety, which in turn increase costs. Despite a number of proposed solutions, ED length of stay (LOS) - a main cause of overcrowding - remains a major issue worldwide. This cohort study was aimed at evaluating the effectiveness on ED LOS of a procedure called “diagnostic anticipation”, which consisted in anticipating the ordering of blood tests by nurses, at triage, following a diagnostic algorithm approved by physicians.

Methods : In the second half of 2019, the ED of the University Hospital of Ferrara, Italy, adopted the diagnostic anticipation protocol on alternate weeks for all patients with chest pain, abdominal pain, and non-traumatic bleeding. Using ED electronic data, LOS independent predictors were evaluated through multiple regression.

Results : During the weeks when diagnostic anticipation was adopted, as compared to control weeks, the mean LOS was shorter by 18.2 minutes for chest pain, but longer by 15.7 minutes for abdominal pain, and 33.3 for non-traumatic bleeding. At multivariate analysis, adjusting for age, gender, triage priority and ED crowding, the difference in visit time was significant for chest pain only ($p<0.001$).

Conclusions : The effectiveness of the anticipation of blood testing by nurses varied by patients' condition, being significant for chest pain only. Further research is needed before the implementation, estimating the potential proportion of inappropriate blood tests and ED crowding status

Background:

The American College of Emergency Physicians defines crowding as a need for emergency services exceeding available resources for patient care in the Emergency Department (ED), hospital or both [1]. In particular, ED crowding is considered a public health issue worldwide [2], because its consequences include diminished patients and staff satisfaction, decreased patients safety (delays in the evaluation and treatment of emergency patients, increased morbidity and mortality), increased costs, and reputation damage [1].

The causes of crowding are multifactorial and include, among the major contributors, the length of stay (LOS) of ED patients [3]. Evidence suggests that lengthy visits impact is more relevant than non-

urgent [4] or frequent visits [5]. One of the main causes of prolonged ED LOS involves the patients flow within the ED and is defined as “throughput” [6]. This period starts from patient’s arrival in ED (triage) to the decision of the physician (admission or discharge).

Many interventions have been tested to improve ED waiting times and LOS [7], including deployment of physicians at triage [8], use of trained scribes to assist ED physicians [9], nurse-initiated diagnostic ordering at triage, based on physician approved algorithms [10], and resident-initiated advanced triage [11]. A systematic review concluded that nurse-initiated diagnostic ordering were effective in reducing ED LOS, but the available evidence was limited, as studies were scarce and of poor methodological quality [12].

Given that the Italian and Regional healthcare government recommended a maximum threshold of six hours for ED LOS, the Ferrara University Hospital introduced nurse-initiated diagnostic ordering at triage at alternate weeks, thus allowing an evaluation of the effectiveness and feasibility.

This cohort study was aimed at evaluating the effectiveness on ED LOS of a procedure called “diagnostic anticipation”, which consisted in anticipating the ordering of blood tests by nurses, at triage, following a diagnostic algorithm approved by physicians.

Methods

Ethics

The study protocol was approved by the Independent Ethical Committee of Area Vasta Emilia Centrale (CE-AVEC, study code: 840/2019/Oss/AOUFe; date of approval CE: 11/12/2019).

Study design and setting

This cohort study was performed at the Emergency Department of the Ferrara University Hospital, a tertiary care hospital in Emilia-Romagna region, Northern Italy, from July 1st, 2019 to December 31, 2019. All participants were monitored during the ED stay, from triage registration to physician’s decision (hospital admission or discharge).

Study population

Inclusion criteria were:

- Hour of visit between 8:00 am and 8:00 pm;
- chest pain, abdominal pain or non-traumatic bleeding;

- Triage priority color code yellow or green. In Italy, triage involves assigning a priority color code to patients arriving at the hospital ED: White = The situation is not an emergency, the patient is safe or does not have a life-threatening condition. Green = The situation is not an emergency; the patient has an acute but stable pathology, and vital signs are normal; Yellow = The situation is a medical emergency. Intervention cannot be delayed; Red = the situation is an absolute emergency. The patient's vital signs have deteriorated or indicate an immediate threat to patient's life [13].

Exclusion criteria were:

- Death or leave of ED before physician's decision.

Procedure

The diagnostic anticipation protocol was implemented on alternate weeks to evaluate its effectiveness before full implementation (and to avoid the history bias that typically afflicts before/after evaluations). During the weeks in which the diagnostic anticipation was adopted, following an algorithm made by the physicians, the nurses at triage ordered the blood tests listed in Table 1 for all eligible patients, before physician's visit. In control weeks, the routine diagnostic pathway - with physicians (eventually) ordering blood tests after the visit - was followed.

Table 1

Nurse-initiated blood test ordering at triage, based on a physician-approved diagnostic algorith

Condition at triage	Blood tests
Chest pain	Complete blood count, creatinine, sodium, potassium, glycemia, cardiac t
Abdominal pain	Complete blood count, creatinine, sodium, potassium, glycemia, Alanir (ALT), bilirubin, C-Reactive Protein (CRP), pancreatic lipases
Non-traumatic bleeding	Complete blood count, creatinine, sodium, potassium, Prothrombin T Thromboplastin Time (PTT)

A multidisciplinary team including the hospital risk manager, ED physicians and nurses, laboratory physicians and IT technicians defined the standard operating procedure: whenever an eligible patient was accepted to ED triage, the nurse selected the above listed blood tests within 15 minutes [14].

When blood tests results become available, the nurse delivered them to the physician for interpretation.

Data Analysis

Data have been collected from administrative ED electronic database. For each visit, the following variables were recorded: age, gender, symptoms at triage, diagnosis, date and hour of triage registration, priority code, medical imaging, specialist consultations, blood tests, physician's decisions about the patient, date and hour of the decision. ED crowding was estimated for each visit through the National ED Overcrowding Study (NEDOCS) score [15].

The statistical significance of the differences between intervention and non-intervention weeks was evaluated using Fisher's exact test for categorical variables, and t-test for continuous variables. Separately for triage conditions, the potential independent association between diagnostic anticipation and ED LOS was evaluated using multiple regression, adjusting for age, gender, priority access codes and NEDOCS score. All analyses were performed using Stata 15.1 (StataCorp, College Station, Texas, USA, 2017). A two-tailed p-value < 0.05 was defined as statistically significant for all analyses.

Results

From July 1st, 2019 to December 31, 2019, 3242 visits were included in the study (1695 during control weeks, 1547 during diagnostic anticipation weeks), out of a total of 30,532 ED visits (Fig. 1). As shown in Table 2, some of the demographic and clinical characteristics of the patients significantly differed during DA weeks, as compared with control weeks. In specific, during DA weeks, the NEDOCS score was higher for all clinical conditions, as well as the number of prescribed blood tests (100%), the mean age of the patients with chest pain was slightly lower, whereas patients with non-traumatic bleeding were older by more than 5 years (which probably explains, for these subjects, the higher rate of hospitalization and yellow priority codes).

Table 2

Emergency department visits characteristics for presenting complaint at triage registration.

Visits characteristics	NON-DA	DA	p-value†
Chest pain, n	530	668	
LOS (min), mean (SD)	345 [157]	327 [123]	0.024
Age (years), mean (SD)	60.0 [18.2]	57.5 [19.6]	0.024
Sex (male), %	51.1	48.1	0.29
NEDOCS (score), mean (SD)	127 [59]	157 [67]	< 0.001
Imaging tests (n), mean (SD)	1.9 [0.9]	1.9 [1.0]	0.60
Blood tests (at least 1), %	97.4	100.0	< 0.001
Specialist consultations (n), mean (SD)	0.15 [0.02]	0.14 [0.01]	0.56
Priority color code (yellow), %	84.2	82.8	0.53
Physicians decision (hospitalization), %	18.3	14.1	0.047
Abdominal Pain, n	846	700	
LOS (min), mean (SD)	341 [167]	356 [149]	0.053
Age (years), mean (SD)	57.0 [22.3]	56.8 [22.2]	0.88
Sex (male), %	42.3	40.4	0.47
NEDOCS (score), mean (SD)	127 [58]	145 [61]	< 0.001
Imaging tests (n), mean (SD)	1.8 [1.0]	1.9 [0.9]	0.46
Blood tests (at least 1), %	92.6	100.0	< 0.001
Specialist consultations (n), mean (SD)	0.29 [0.02]	0.29 [0.02]	0.75
Priority color code (yellow), %	51.5	56.3	0.06
Physicians decision (hospitalization), %	28.6	27.3	0.57
Non-traumatic bleeding, n	301	179	
LOS (min), mean (SD)	304 [147]	337 [166]	0.023
Age (years), mean (SD)	67.9 [20.2]	73.4 [16.5]	0.002
Sex (male), %	61.8	53.6	0.08
NEDOCS (score), mean (SD)	129 [58]	143 [68]	0.016
Imaging tests (n), mean (SD)	1.3 [0.6]	1.4 [0.7]	0.77
Blood tests (at least 1), %	86.4	100.0	< 0.001
Specialist consultations (n), mean (SD)	0.49 [0.03]	0.40 [0.04]	0.09
Priority color code (yellow), %	50.4	62.6	0.004
Physicians decision (hospitalization), %	26.6	35.8	0.034
Abbreviations: DA = Diagnostic Anticipation; LOS = Length of Stay; SD = Standard Deviation; NEDOCS = National ED Overcrowding Study Score[15] at triage registration; min = minutes.			
†calculated through Pearson's $\chi 2$ test for categorical variables and T-Student test for continuous variables.			

During DA and control weeks, respectively, the following mean ED LOS were recorded (Table 2):

− 327 ± 123 versus 345 ± 157 minutes for the patients with chest pain (univariate p = 0.024);

− 356 ± 149 versus 341 ± 167 minutes for the patients with abdominal pain (p = 0.053);

− 337 ± 166 versus 304 ± 147 minutes for the patients with non-traumatic bleeding (p = 0.023).

Multivariate analyses

Multivariate analyses showed that, for the patients with chest pain, ED LOS was significantly reduced

during DA weeks: regression coefficient: -29.2 minutes; 95% Confidence Interval - CI: -44.9; -13.5 (adjusted $p < 0.001$ - Table 3). In contrast, ED LOS did not significantly differ during DA and control weeks for the patients with abdominal pain ($p = 0.50$) and non-traumatic bleeding ($p = 0.26$). The other independent predictors of ED LOS were higher age and NEDOCS score (for all patients), yellow priority code (only for the patients with chest or abdominal pain), and male gender (for patients with abdominal pain only).

Table 3
Multiple regression model predicting ED length of stay.

	Chest Pain				Abdominal Pain				Non-Traumatic Bleeding			
	β	95% CI		p	β	95% CI		p	β	95% CI		p
Diagnostic Anticipation	-29.2	-44.9	-13.5	< 0.001	5.3	-10.1	20.8	0.50	16.2	-11.9	44.4	0.26
Age, 5-year increase	7.11	5.0	9.2	< 0.001	4.8	3.0	6.6	< 0.001	4.7	1.1	8.3	0.01
Male gender	8.9	-6.3	24.2	0.25	25.9	10.4	41.3	0.001	-1.3	-28.6	26.0	0.92
NEDOCS score, 10-point increase	4.6	3.4	5.8	< 0.001	6.4	5.1	7.8	< 0.001	6.5	4.3	8.7	< 0.001
Yellow priority code (vs green)	37.7	16.5	58.9	< 0.001	24.1	8.2	40.0	0.003	-22.3	-49.8	5.3	0.11

Abbreviations: NT = Non Traumatic; β = β coefficient; CI = Confidence Interval, DA = Diagnostic Anticipation; NEDOCS = National ED Overcrowding Study Score[15] at triage registration.

Discussion

In this field, observational study, the introduction of protocol of blood testing diagnostic anticipation in ED showed contrasting results: although the ED was reduced by approximately 30 minutes for the patients presenting with chest pain, no impact was observed for the patients with abdominal pain and non-traumatic bleeding. Also, with regard to chest pain, the observed reduction in LOS was shorter than the mean difference of 51 minutes reported in a systematic review on triage-nurse ordering [12]. The potential explanations for the observed smaller, or zero impact, are manifold. First, the average ED LOS in the study hospital was long for all patients, approaching 6 hours, which may dilute the impact of anticipating blood testing. Second, the studies included in the above mentioned review mostly regarded triage initiated x-rays, and only 2 studies out of 14 also considered blood tests [12].

Moreover, of the two studies including blood tests, one was an unpublished dissertation, and the other had a weak methodology [10]. Third, the DA protocol was implemented for the first time during the six months of the study, and the adoption of the algorithm by triage nurses was certainly suboptimal, especially in the first months. Finally, with regard to the different findings on chest pain and abdominal pain or non-traumatic bleeding, this may be due, at least in part, to the lower proportion of blood testing that were performed during control weeks for the subjects with abdominal pain or non-traumatic bleeding, as compared to those with chest pain. Performing a lower number of blood tests could clearly result into a shorter LOS, jeopardizing the potentially positive impact of anticipation. Certainly, further research is needed to clarify these points, as well as to confirm of disprove the benefit of diagnostic anticipation for the patients with chest pain.

The other results of the multivariate analyses were straightforward: a longer ED LOS was observed for older patients, with upper priority code, during the periods of higher ED crowding (higher NEDOCS score). Noteworthy, female patients with abdominal pain showed a significantly longer LOS than males. This could be explained by the fact that abdominal pain has gender-specific diagnostic differences (for example gynecological conditions). Again, further, specific studies are warranted to investigate the potential gender difference on LOS and its potential organizational consequences.

Limitations

First, in this study the diagnostic anticipation protocol was limited to the daily hours of service from 8:00 am to 8:00 pm, due to a limited availability of resources (nurses in service) during night shifts. However, during the nights, ED crowding is typically lower.

Second, triage-initiated blood testing requires a crowded ED in order to detect a positive impact on LOS: in uncrowded ED patients are immediately, or after a very short waiting time, addressed to physician’s evaluation, and it may not be observed any LOS reduction from anticipated testing. In this study, the mean NEDOCS score ranged from 120 (overcrowded) to 160 (severely overcrowded). Thus, the findings of this study cannot be generalized to Emergency Departments with low crowding status and short waiting times before physician’s evaluation.

Conclusions:

The introduction of a protocol of diagnostic anticipation of blood tests at triage, into a crowded Emergency Department, showed contrasting results: the LOS was significantly reduced, by approximately 30 minutes, for the patients reporting chest pain, whereas no impact was observed for the patients with abdominal pain or non-traumatic bleeding. Although the impact of diagnostic anticipation could be substantial in reducing the ED waiting time, further research is required to confirm the positive findings and investigate the potential reasons of the observed discrepancies by clinical condition.

Abbreviations

ED

Emergency Department

LOS

Length Of Stay

ALT

Alanine Transaminases

CRP

C-Reactive Protein

PT

Prothrombin Time

PTT

Partial Thromboplastin Time

NEDOCS

National Emergency Department OVercrowding Study

DA

Diagnostic Anticipation

SD

Standard Deviation

Declarations

ETHICS APPROVAL AND CONSENT TO PARTICIPATE:

The study protocol was approved by the Independent Ethical Committee of Area Vasta Emilia Centrale (CE-AVEC, study code: 840/2019/Oss/AOUFe; date of approval CE: 11/12/2019). The Ethical Committee reviewed the study protocol and deemed it to be the evaluation of a quality improvement initiative and waived the need for informed consent according to current national legislation

("Provvedimento 176/2019 del Garante della Privacy – Provvedimento recante le prescrizioni relative al trattamento di categorie particolari di dati, ai sensi dell'art. 21, comma 1 del d.lgs. 10 agosto 2018, n. 101"). Data collection was conducted following the principles of the Declaration of Helsinki, according to current national legislation and in compliance with the protection of personal data.

CONSENT FOR PUBLICATION:

Not applicable

AVAILABILITY OF DATA AND MATERIALS:

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

COMPETING INTERESTS:

The authors declare no conflict of interests

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AUTHORS' CONTRIBUTIONS:

AS conceived the study, contributed to interpretation of data and revised the work

NB, LM contributed to analysis, interpretation of data and were major contributors in writing the manuscript

LM, GV, CM contributed substantively to the analysis of data and methodology

RB, AP contributed to conceptualization of the study

EF contributed to acquisition of data

FB, AS, EDR, TC, substantially revised the work

All authors read and approved the final manuscript.

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Not applicable

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Figures

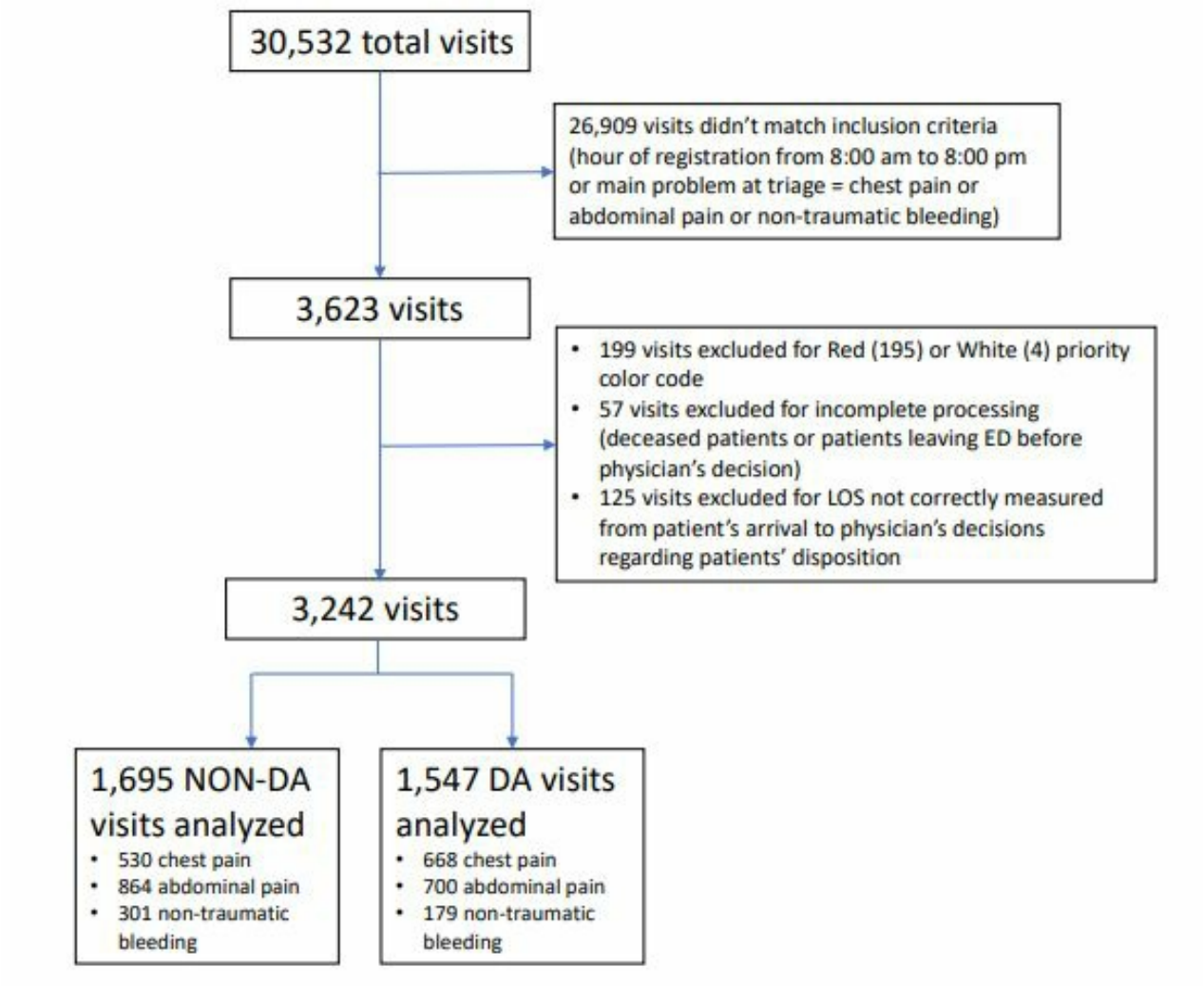

Figure 1

Study profile Abbreviations: ED=Emergency Department; LOS= Length of Stay; DA= Diagnostic Anticipation