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Pulmonary embolism risk assessment: application of the Revised Geneva Score in an emergency department

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ABSTRACT

Aims: The Revised Geneva Score (RGS), a standardized Clinical Prediction Rule for Pulmonary Embolism (PE), was recently developed. We have measured its predictive accuracy, performing an external retrospective validation in a cohort of Emergency Department (ED) patients, filtered by symptomatology and not by clinical suspicion, to allow its use in nursing practice.

Methods: The clinical probability of PE was assessed in 1013 consecutive patients with symptoms of "chest pain" or "shortness of breath/dyspnea", whose clinical records were obtained during a two months period, in an Italian ED. The accuracy of RGS was analyzed by the Receiver Operating Characteristic (ROC) analyses; the OR was evaluated with an analysis of the risk raw score.

Results: The overall prevalence of PE was 1.09%. The prevalences of PE in the three probability categories were similar and not statistically significant. The Area under the Curve was 0.6373 (CI 0.4336-0.8409). However, the NPV was 0.993 (95% CI 0.981-0.998) and the mean score of risk was 3.36 for the 1002 not affected by PE and 5.73 for the 11 subjects with Pulmonary Embolism (p 0.0003), by exclusively assessing it on the raw score obtained.

Conclusions: This study suggests that the performance of the RGS, modified in order to be applied to a nursing emergency approach, gives good results in NPV; it should be also tested to assess the embolic risk by a dichotomous numerical score (rule-in/rule-out), that should be used to supplement rather than as a substitute for clinical judgement.

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1. Introduction

According to a statement from the American Heart Association [1] the Venous Thromboembolism (VTE) is responsible for the Acute Care Hospitalization of more than 250,000 Americans annually, resulting in a highly significant risk of morbidity and mortality in the population, with an annual incidence that settles between 0.5 and 1 per 1,000 [2].

VTE includes, among its manifestations featuring greater severity and criticality clinical progress, sub-massive and massive pulmonary embolism (PE), that leads to 100-300,000 deaths annually in the U.S. alone [3].

White R., in 2003, asserts that death occurs, within a month from the acute event, in the 12% of affected patients [4].

In the United Stated the pulmonary embolism prevalence is 0.4% [5] and in Italy the incidence rate is 65,000 new cases per year [2].

In order to reduce mortality it is necessary that diagnosis is quickly confirmed and the therapy starts as soon as possible [6]. Early recognition and consequent immediate treatment could reduce the mortality rate from 30 to 1.5% [7].

Pulmonary embolism is a definitely fatal clinical situation, extremely varied in its manifestations, as summarized by the Guidelines and Expert Consensus Documents of the European Society of Cardiology [5], which recommend assessing at the earliest the level of pulmonary embolism risk, through standardized and validated Clinical Prediction Rules (CPRs).

Although the predictive pre-test evaluation alone cannot confirm or rule-out the clinical condition, it permits to discriminate suspected PE patients into categories of clinical pretest probability, corresponding to an increasing prevalence of PE. This approach could lead to a more effective management of the clinical picture itself, supporting the interpretation of laboratory and instrumental test results, besides the definition of diagnostic and therapeutic strategy to be implemented [5].

The literature cites multiple standardized tools for estimating the risk of PE in clinical pre-diagnostic conditions, such as the Wells Score [8], the Simplified Wells Score [9], the Geneva Score [10], the Revised Geneva Score [11] and the Simplified Revised Geneva Score [12], defining the Wells Score and Revised Geneva Score as the most used in clinical settings.

The use of Wells, Geneva and Revised Geneva Score (RGS) expects to take into account the patient's typology (in/outpatients) and the prevalence of the disease in the population.

In Klok's publication [13] the widely used Wells and Revised Geneva Score are compared, in relation to their performance and their usefulness for ruling out PE, in combination with D-dimer measurement. The performance of RGS did not statistically differ from the Wells rule and it seems safe to exclude PE by the combination of a low or intermediate clinical probability, with a normal D-dimer level.

Douma [14] proceeds with a multicenter prospective observational study to compare in terms of safety and clinical utility 4 CPRs, Wells Rule, Revised Geneva Score, Simplified Wells rule and Simplified Revised Geneva Score, investigating their efficacy to exclude a framework of PE, in combination with D-dimer test. The study shows how the performance of the scores is equivalent, allowing the CPRs to exclude with reasonable certainty the risk of embolism among patients with a result of "PE-unlikely" (cutoff of 5 points or less), in combination with a normal D-dimer, without the need for additional imaging. When not combined with the D-dimer test result, the sensitivities of the various CPRs did not differ, although there were small differences in specificity. The negative predictive value (NPV) was 99.5 (97-100).

The purpose of this study is to find a potentially implementable CPR in nursing practice. The nurse is in fact the health professional who first approaches the outpatient in need of urgent care, in an Emergency Room setting. The procedural goal is to ensure a rapid assessment

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of subjects, reducing the waiting time for patients in critical condition or clinical instability, limiting the risk of clinical worsening.

2. Methods

2.1 Type of study

This is a retrospective monocenter observational study on clinical accuracy of Revised Geneva Score, applied to consecutive outpatients, admitted in an Emergency Department (ED).

2.2 Study population

Consecutive outpatients, admitted in an Emergency Department.

Inclusion criteria were age ≥18 years, sign and symptoms of "chest pain" or "shortness of breath/dyspnea" [15], while exclusion criteria were "dyspnea" or "chest pain" of traumatic origin and individuals whose clinical data were missing.

The sample size was calculated in relation to the disease incidence rates in the general population (0.5/1 per 1000) and in reference to the proportion that had the selected criteria during a calendar year of Emergency Room visits.

2.3 Timing and Setting

The data were collected from records of the Emergency Department of the "Maggiore Della Carità" University Hospital in Novara in the period between the 11th of April 2012 and the 24th of June 2012.

2.4 Instrument

The best validated and therefore most widely used CPRs are the Wells rule and the Geneva score [13]. As reported by Kirle [16] the Revised Geneva Score represents a simplification of the original Geneva Score [10]. It is entirely based on clinical easily identifiable variables, while remaining independent of the physician's judgment. It investigates data like age, previous PE or Deep Venous Thromboembolism (DVT), recent surgery or trauma, malignancy, unilateral lower-limb pain, hemoptysis, heart rate, pain on lower-limb deep venous palpation and unilateral edema (Table 1).

The Revised Geneva seems to be potentially implementable in emergency nursing practice; it is in fact more suited to an Italian setting, as being validated on a wide European population and also on an external population. The items investigated are exclusively represented by signs, symptoms and medical history, excluding the intervention of the physician. It allows classifying patients in 3 categories of clinical probability (low-intermediate-high risk) [11].

2.5 Ethics approval of study

No particular ethical problems have been detected. The management of sensitive data has been filtered only through researcher's limited access. The patients were not identified by name, but only through the ER access-code. The study was performed in accordance with good clinical practice, and the study applies the guidelines of The Declaration of Helsinki. It was approved by the Chief Physician and Director-General at "Maggiore Della Carità" University Hospital, Novara.

2.6 Statistical analysis

The data processing involved the determination of the frequency distribution and relative measures of central tendency and dispersion for the main sample characteristics, such as age, sex, incidence of disease and the presence/absence of information investigated by single RGS items, calculated both on the total population and only on embolic patients.

A comparative analysis between embolic and non-embolic for presence/absence of each single item under investigation was applied, followed by the Pearson Test, so calculating the $\chi 2$ in order to obtain the p-value.

After that, the distribution "embolic" vs. "non-embolic" for different level of risk stratification was calculated, using both the tripartite

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low/intermediate/high and the low/medium+high risk score, applying the Fisher Test.

The evaluation of the prediction accuracy was obtained by calculating the Sensitivity (SN), Specificity (SP), Positive Predictive Value (PPV) and Negative Predictive Value (NPV), Likelihood Ratio + / -, with representation of the relative AUC (Area Under the Curve) in a ROC (Receiver Operating Characteristic) analysis.

The OR (Odds Ratio) and p-value were calculated working on an assessment geared exclusively on the numeric score of risk, comparing "embolic" vs. "non- embolic". Any comparisons between quantitative variables were performed by T (Student's) test.

Any comparisons between nominal variables were performed by the Pearson test or the Fisher's test.

The minimum level of significance for which the null hypothesis is rejected was set at p values <0.05.

3. Results

The study analyzed 1144 patients with symptoms of "chest pain" or "shortness of breath/dyspnea", whom clinical records were obtained and analyzed during the period between April 11th and June 24th, 2012, out of a total of 5838 patients referred during the year. We excluded 131 subjects: underage (n=62, 47.33%), 55 (41.98%) missing data and 14 (10.69%) symptoms of traumatic origin.

3.1 Characteristics of study population

The study population consists of 1013 subjects, with a predominance of males (n=526, 51.92%) and a mean age of 61.37 years (SD 19.63). Overall, female subjects are of higher average age (63.09 - SD 20.82) (See Table 2).

As shown in Table 2, previous embolism or DVT are reported in only 1.09% of the population (Item 2), we have a low percentage of previous surgery or lower-limb fractures (1.48%) (Item 3), while the most represented data is any condition of malignancy (3.26%) (Item4).

Table 1

The Revised Geneva Score

VARIABLE	SCORE
Age> 65 y	+1
Previous DVT or PE	+3
Surgery (under general anesthesia) or fracture (of the lower-limbs) within 1 month	+2
Active malignant condition (solid or hematologic malignant condition, currently active or considered cured < 1y)	+2
Unilateral lower-limb pain	+3
Hemoptysis	+2
Heart rate 75 - 94 bpm	+3
Heart rate ≥95 bpm	+5
Pain on lower-limb deep venous palpation and unilateral edema	+4

SCORE	*Clinical probability*
0-3 total	*Low*
4–10 total	*Intermediate*
≥11 total	*High*

(Le Gal et al., 2006)

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Table 2

Demographic and General characteristics of the study population: analysis by RGS items

Population	RGS Item	Total
Gender (Male, n, %)		526 (51.92)
Age (Mean years ± SD)		61.37 (19.63)
Age > 65 (n, %)	Item 1	466 (46)
Previous DVT o PE (n, %)	Item 2	11 (1.09)
Surgery (under general anesthesia) or fracture (of the lower limbs) within 1 month (n, %)	Item 3	15 (1.48)
Active malignant condition (solid or hematologic malignant condition, currently active or considered cured < 1y) (n, %)	Item 4	33 (3.26)
Unilateral lower-limb pain (n, %)	Item 5	4 (0.39)
Hemoptysis (n, %)	Item 6	1 (0.10)
Heart rate 75-94 bpm (n, %)	Item 7	470 (46.44)
Heart rate ≥ 95 bpm (n, %)	Item 8	279 (27.57)
Pain on lower-limb deep venous palpation and unilateral edema (n, %)	Item 9	3 (0.30)

Table 3

Stratification of the study population for clinical probability

Score	Total
Low (n, %)	544 (53.70)
Intermediate+High (n, %)	(466+3) 469 (46.30)
Total (n, %)	1013 (100)

The heart rate results in 27.57% of cases ≥95 bpm (Item 8).

The incidence of disease, in reference to Primary and Secondary ER Diagnosis, is 1.09% (n=11).

3.2 Clinical Score

A clinical RGS risk score, ranging from 0 to 25 points, was established through the analysis of the database of 1013 patients admitted to the Emergency Ward for "chest pain" or "shortness of breath/dyspnea".

Five hundred and forty four patients (53.7%) had a total score of 3 or less, whilst four hundred and sixty nine patients (46.3%) had a total score of 4 or more (Table 3).

The PE risk, RGS assigned, moves from a maximum value of 17 to a minimum value of 0, with a mean score of 3.38 (SD 2.15)

The difference in prevalence of PE in the 2 categories (low and intermediate high- "PE-unlikely"/cutoff of 3 points or less) shows a p value of 0.363 (Table 4).

The calculation of Sensitivity (SN), Specificity (SP), Positive Predictive Value (PPV), Negative Predictive Value (NPV), Likelihood Ratio (LR +/-) can be summarized in the following table (Table 5).

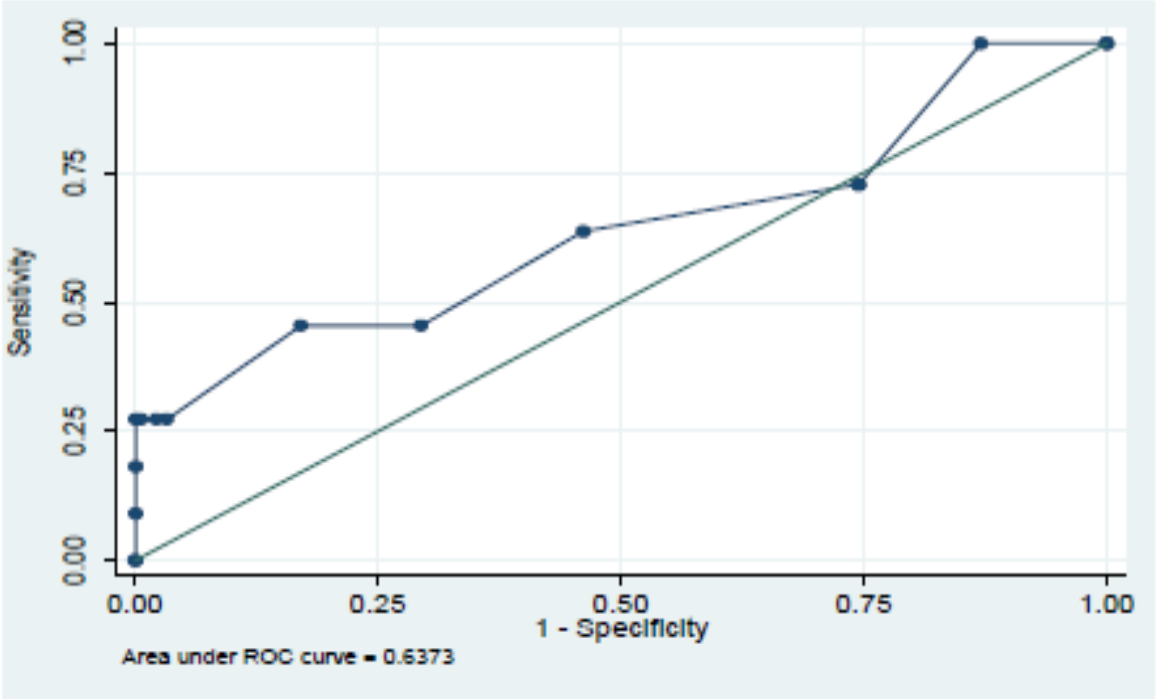
The results are summarized in the following Receiver Operating Characteristic Curve (Figure 1).

Operating an assessment geared exclusively on raw score obtained on the same sample, as a pure numeric value, the mean score of risk results 3.36 for the 1002 not affected by the disease and 5.73 for the 11 subjects relapsed within a framework of pulmonary embolism.

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Figure 1.

ROC Curve



Obs	ROC Area	Std.Err.	[95% Conf.	Interval]
1013	0.6373	0.1039	0.43363	0.84091

The difference between the mean risk scores shows a p value of 0.0003 (Table 6).
The Odds Ratio is 1.4307 (CI 1.1751-1.7418), indicating that two subjects with scores respectively x1 and x2 such that x1-x2 = 1, have a relation between their Odds presence of embolism of 1.43 (Table 7).

4. Discussion

This study represents a first step to identify and validate a CPR potentially adaptable to the nursing practice.

This assumption has led to a careful evaluation of criteria as safety, applicability and clinical utility of the instrument.
The choice of the Revised Geneva Score results in a clinical accuracy research, potentially allowing predicting or excluding the probability of PE before doing specific tests, such as D-dimer measurement, lung scan and pulmonary angiography [5].
With the availability of conclusive data we did a first comparison of the population sample to the population described in the original study [11], which consisted in 965 subjects filtered by "suspected embolism".

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Table 4
Comparison between PE diagnosis and Clinical Probability

	Clinical Probability		Total (n)
Pulmonary Embolism	*Low (n)*	*Int.+high (n)*	
No	540	462	1002
Yes	4	7	11
Total	544	469	1013

p value = 0.363

The mean age of the sample (61.37 y) is not significantly different from the mean age in the original population (60.6 y) (p 0.3805), while the gender distribution is shifted toward the male component (p 0.000), prevalent in this study.

We can also see that the population described by Le Gal [11] is more represented in terms of previous DVT or PE (Item 2), surgery (under general anesthesia) or fracture (of the lower limbs) within 1 month (Item 3), active malignant condition (Item 4), and pain on lower-limb deep venous palpation and unilateral edema (Item 9) (p 0.000 for all comparison).

In our population the prevalence of PE is 1.09%.The data processing was carried out on a large sample, whose majority is constituted by "non-embolic patients" (n=1002), in opposition to 11 subjects diagnosed for the disease.

The application of the instrument showed no statistically significant difference between embolic and non-embolic population (p=0.363). The analysis of sensitivity, specificity and ROC Curve, where the lower bound of the confidence interval is less than 0.5 (0.4336< 0.5), enables to assert that we cannot reject the null hypothesis (the test therefore has no discriminant ability).

However, the usefulness of diagnostic tests, that is their ability to detect a person with disease or exclude a person without disease, is usually described by terms such as SN, SP, and also PPV and NPV. The NPV of a test is the proportion of people with a negative test result, who do not have disease; in this case is 0.993 (CI 95% 0.981-0.998) and this means that 99.3% of people testing negative for RGS will not have PE or, put in another way, a person who has a negative test has a 99.3% chance of

Table 5
Accuracy

Index	Value	CI (95%)	
SN	0.636	0.308	0.891
SP	0.539	0.507	0.570
PPV	0.015	0.006	0.031
NPV	0.993	0.981	0.998
LR+	1.380	0.879	2.168
LR-	0.675	0.308	1.478

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Table 6:
Raw score assessment, comparison between PE vs no PE mean scores

PE	Obs.	Mean	Std. Err.	Std.Dev.	CI (95%)	
No	1002	3.356287	.0662016	2.09557	3.226378	3.486197
Yes	11	5.727273	1.414798	4.692354	2.574907	8.879639
Combin.	1013	3.382034	.0675454	2.149812	3.249488	3.514579
Diff.		-2.370985	.6477855		-3.642143	-1.099827

p= 0.0003

not having PE.
Obviously this CPR and its good NPV should be used to supplement rather than as a substitute for clinical judgement and reasoning.
Besides, the analysis conducted on the risk raw mean score showed a statistically significant difference between the two subpopulations ("embolic" and "no embolic") and an OR> 1 (1.430696 - CI 1.175146-1.741819) (Table 7).

Limitations
Although the data required for the calculation of the score were obtained from computerized documentation, the focus on paperless medical records did not allow, in certain cases, to have a complete and comprehensive description of the clinical situation, especially in case of emergency, hypothetically reducing the available details and therefore jeopardizing the accuracy of risk stratification.
Besides, no data have been acquired from the Department of Infantile Science, due to the exclusion criteria.

Implication for Emergency Nurses
What are the possible future developments and implications in clinical practice?
Despite first negative feedback in terms of predictability, associated with attribution to a risk category, the results obtained on the NPV and the risk raw mean score make it easier to envisage the possibility of carrying out further research designed to actively apply another variant of the original formulation of the instrument. It could be applied, therefore, not only to make a first selection of patients to be tested in relation to specific entry criteria, but also to assess embolic risk stratification by dichotomous numerical score (rule-in/rule-out), and not by size of clinical risk.
The instrument could also be easily computerized and integrated into any ER acceptance database software of the Emergency Department, allowing an immediate return in terms of patient allocation and support further diagnostic investigations.

5. Conclusions
The purpose of this study stems from the need to identify a Clinical Prediction Rule which allows an early detection of pulmonary embolism in nursing practice. The RGS is only based on signs, symptoms and medical history, and it excludes the intervention of the

Table 7
Odds Ratio

PE	OR	Std. Err.	Z	P value	CI (95%)	
Score	1.430696	.1436335	3.57	0.000	1.175146	1.741819

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physician. It allows classifying patients in 3 categories of clinical probability.

The application of the instrument in the classical formulation, range risk distribution, showed no statistically significant difference between embolic and non-embolic subjects (p=0.363), but a NPV of 0.993 (CI 95% 0.981-0.998).

The analysis conducted on the risk raw mean score showed a statistically significant difference between the two subpopulations (embolic and non-embolic) and an OR> 1 (1.430696 - CI 1.175146-1.741819).

This could encourage starting up a derivative research study, in order to test, by estimating the cutoff point on a larger population, the identification of two dichotomous risk classes, high and low. This value will presumably aim to increase the sensitivity of the test, leading to a reduction of false negatives.

In conclusion, the study represents a retrospective application of the Revised Geneva Score, widely used in clinical practice by physicians, but integrated and tested for the first time for nursing practice, through the inclusion criteria of the target population for symptoms like "dyspnea" OR "chest pain", and not for clinical suspicion of pulmonary embolism. We believe that our findings could encourage further studies in nursing practice, which could have a good impact on the quick identification or ruling out in suspected pulmonary embolism patients.

Contributors

All authors contributed to the conception and design of the study; all authors contributed to the analysis and interpretation of data, and all authors revised it critically and approved the final version.

All authors had full access to all of the data (including statistical reports and tables) used in the study and take responsibility for the integrity of the data and the accuracy of its analysis.

Conflict of interests

The authors indicated no potential conflicts of interest.

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