PREHOSPITAL CARE

Evaluation of a risk score for interhospital transport of critically ill patients

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Background: Interhospital transfer imposes essential risk for critically ill patients. The Risk Score for Transport Patients (RSTP) scale can be used as a triage tool for patient severity.

Methods: In total, 128 transfers of critically ill patients were classified in two groups of severity according to the RSTP. Statistical analysis was performed using the receiver operating characteristic (ROC) curve and goodness of fit statistics.

Results: In total, 66 patients (51.5%) were classified as group I and 62 (48.4%) as group II. Major en route complications were more common in group II patients (19.3% v 3%, $p < 0.001$). Haemodynamic instability was the most common complication. There were significant differences in the mean risk scores between group I and II patients (mean (SD) 4.48 (1.01) v 11.04 (3.47), $p < 0.001$). Discrimination power of RSTP was acceptable (area under the ROC curve 0.743; cutoff value ≥ 8). Goodness of fit was adequate ($p = 0.390$).

Conclusion: The RSTP had acceptable discrimination and adequate goodness of fit and could be considered as a triage tool. Haemodynamic instability is the most common problem encountered during transfer.

Interhospital transfer of critically ill patients is common, even in countries with well developed health care systems.¹ Patients with unresolved, evolving, or incompletely evaluated life threatening conditions are transferred to other hospitals, often under substandard care.^{1–2} The main reasons for interhospital transfers are lack of intensive care unit (ICU) beds, specialists, diagnostic tools, and therapeutic means.^{3,4} Interhospital transfer of critically ill patients imposes essential risks for both patients and personnel, thus a well established risk to benefit ratio should exist to justify the procedure.^{1–8} Whichever system of transport is followed, a well validated scale of risk of transport is needed for the best selection of the means and personnel to be used.^{5–10}

In Greece, a hospital based team of doctors, mainly from the anesthesia department, carries out interhospital ground transports of critically ill patients. In our hospital, the lack of qualified emergency physicians forced the ICU medical staff and the anesthetists to assume this task. The objective of our study was to validate the performance of the recently proposed Risk Score for Transport Patients (RSTP; tables 1–3), in predicting patients most likely to develop major complications during interhospital transport, and deciding on the most appropriate means of transport.⁹

PATIENTS AND METHODS

Our hospital is a 230 bed community hospital with seven ICU/critical care unit (CCU) beds. It provides health care for some 100 000 people (the number increases significantly during the summer months). Our ICU can provide intensive care to all critically ill adult patients except for those in need of neurosurgical or cardiothoracic intervention or paediatric ICU. These patients after initial stabilisation and evaluation are transferred to the University Hospital of Heraklion, 80 km away (mean of 60 minutes' driving time, range 55–65 minutes).

All critically ill patients transported to University Hospital, Heraklion during a 1 year period (1 November 2001 to 31 October 2002) were prospectively included in our study. Recommendations for uniform reporting of data following

major trauma were followed; the Utstein style was used to state patients with multitrauma.¹¹ After initial evaluation and stabilisation, patients in need for transport were classified into two groups of severity using RSTP. Group I comprised patients scoring < 7 points and group II comprised patients scoring ≥ 7 points.

Patients were transported by a surface ambulance (a mobile ICU) equipped with all the necessary means for continuous advanced life support. The transport team for group I patients consisted of a doctor qualified in advanced life support (usually a trainee in ICU) and two paramedics. Group II patients were escorted by a qualified intensive care physician, or an anaesthetist in the case of children or neonates. Patients > 12 years old were considered as adults.

Death during transport, major en route complications, ICU admission, and the ICU mortality rate of transferred patients were recorded. En route complications were defined as minor if they could be solved without any invasive intervention or additional pharmacological treatment (other than sedation).

Major complications were defined as: cardiac or respiratory arrest, decrease of > 3 points in Glasgow Coma Score (GCS), fall of $\text{PaO}_2/\text{FiO}_2$ ratio by > 50 or decrease in SaO_2 by $> 5\%$ in adults or $> 3\%$ in children/neonates, hypertension (systolic blood pressure (SBP) > 200 mm Hg), hypotension (SBP ≤ 90 mm Hg), life threatening arrhythmias, or en route need of any invasive procedure.

Statistical analysis

Groups were compared by t test for continuous variables and by χ^2 test for categorical data. Descriptive statistics were expressed as mean (SD) unless otherwise stated. Statistical significance was set at $p = 0.05$. The discrimination of the RSTP was tested using the receiver operating characteristic

Abbreviations: AUC, area under the curve; CCU, critical care unit; GCS, Glasgow Coma Score; ICU, intensive care unit; LRPT, likelihood ratio of positive test; NPV, negative predictive value; PPV, Positive predictive value; ROC, receiver operating characteristic; RSTP, Risk Score for Transport Patients; SBP, systolic blood pressure

(ROC) curve and area under the curve (AUC).¹² This curve is a plot of sensitivity versus 100% specificity. Accuracy can be obtained by calculating the AUC. An accuracy of 1.0 is optimum and an area of 0.5 indicates no discriminatory capacity in the entire test. As previously suggested, we aimed to classify AUC between 0.7 and 0.8 as "acceptable" and between 0.8 and 0.9 as "excellent" discrimination.¹³ The prognostic performance of the RSTP was analysed by sensitivity, specificity, overall correctness of prediction, positive (PPV) and negative predictive values (NPV), and likelihood ratio of positive test (LRPT).¹⁴ The LRPT is a function of sensitivity and specificity according to the following formula: sensitivity/(100%–specificity). In other words, the LRPT indicates the extent to which a positive test result will increase the probability of the event under consideration. Likelihood ratios of 1–2 alter probability to a small and rarely important degree, whereas those of 2–5 generate small but sometimes important change in probability. Likelihood ratios of 5–10 and those >10 generate moderate and large shifts from pre-test probability respectively. All the above variables were calculated both at the cutoff point originally suggested ($\geq$ than 7), and at the cutoff value giving the best Youden index.^{9–15} Calibration of the RSTP was assessed using the Hosmer-Lemeshow goodness of fit statistic, which divides subjects into deciles based on predicted probabilities of death and then computes a χ^2 from observed and expected frequencies.¹⁶ Lower χ^2 values and higher p values are associated with a better fit. A good fit was defined as $p > 0.05$.

RESULTS

In total, 128 patients (91 male and 37 female patients; median age 48.5 years, range 0–92) were prospectively enrolled in the study. Most of the transports (54%) occurred during non-working hours (between 1600 and 0800 on working days) or during weekends. The mean transport time was 58 minutes (range 50–70).

Of these, 66 patients (51.5%) were classified as group I (43 adults, 12 children, and 11 neonates), and 62 patients (48.4%) as group II (53 adults, 4 children, and 5 neonates). Underlying diseases and grouping of patients with regard to RSTP are listed in table 4.

The mean (SD) age of group II adult patients was younger than that of group I adult patients (57.9 (20.6) v 50.2 (22.1); $p = 0.041$). The mean RSTP for group II patients was significantly higher than that of group I patients (11 (3.4) v 4.8 (1); $p < 0.001$).

Invasive intervention (placement of a temporary intravenous pacemaker placement) prior to transport was considered necessary for five group I patients. In contrast, all group II patients had arterial and central venous lines in situ prior to transfer, 42 (71.6%) were receiving inotropes, and 45 (72.5%) were intubated.

No deaths occurred during transfer. Two major complications (hypertensive crisis in patient 1 and aspiration in patient 2; table 5) were encountered during the transfer of group I patients.

One patient died in the operating room during the following 24 hours; however, his death was considered to be unrelated to transfer. Of 66 group I patients, 16 (24.2%) were admitted to ICU/CCU at the receiving hospital during the subsequent 24 hours following transfer. Four died in ICU (overall group I mortality 7.5%; ICU mortality of group I patients 25%). In contrast, 12 group II patients (19.3%) developed major en route complications ($p < 0.001$ compared with group I patients). Rapid deterioration of consciousness level in a head injured patient (patient number 8; table 5) required tracheal intubation en route. Acute pulmonary oedema in a patient with acute myocardial infarction (patient

Table 1 Risk Score for Transport Patients*

Measurement	Score
1. Haemodynamics	
Stable	0
Moderately stable (requires volume <15 ml/min in adults)	1
Unstable (requires volume >15 ml/min or inotropics or blood)	2
2. Arrhythmias (existing or probable)	
No	
Yes, not serious (and AML after 48 hours)	1
Serious (and AML in the first 48 hours)	2
3. ECG monitoring	
No	0
Yes (desirable)	1
Yes (essential)	2
4. Intravenous line	
No	0
Yes	1
Pulmonary artery catheter	2
5. Provisional pacemaker	
No	0
Yes (not invasive). Always AML in the first 48 hours	1
Yes (endocavity)	2
6. Respiration	
Respiratory rate between 10 and 14 breaths/min in adults	0
Respiratory rate between 15–35 breaths/min in adults	1
Apnoea <10 or >36 or irregular breathing	2
7. Airway	
No	0
Yes (Guedel tube)	1
Yes (intubation or tracheostomy)	2
8. Respiratory support	
No	0
Yes (oxygen therapy)	1
Yes (mechanical ventilation)	2
9. Assessment	
GCS = 15	0
GCS 8–14	1
GCS <8 and/or neurological disorder	2
10. Prematurity	
Newborn >2000 g	0
Newborn between 1200 and 2000 g	1
Newborn <1200 g	2
11. Technopharmacological support (actual or en route)	
None	0
Group I	1
Group II	2

*Adapted from Etxebarria MJ *et al.*⁹

Table 2 Appendix A to table 1: medication for risk groups

Group I
Inotropics
Vasodilators
Antiarrhythmics
Bicarbonate
Analgesics
Antiepileptics
Steroids
Manitol 20%
Trombolytics
Naloxone
Thoracic tube
Suction
Group II
Inotropics + vasodilators
MAST
Infant incubator
General anaesthetics
Uterine relaxants

number 12; table 5) was effectively treated by continuous positive airway pressure application, 100% oxygen administration, and intravenous frusemide. The remaining major

Table 3 Appendix A to table 1: management of at risk patients

Points	Group	Vehicle	Staff
0–2	0	Conventional ambulance	None
3–6	I	Conventional ambulance	Nurse
Over 6	II	Group ICU	Doctor + nurse

problems recorded in group II patients were cardiovascular instability (shock in eight cases, hypertension in two; table 5). Shock was related to trauma in six of eight patients (table 5). All group II patients were directly admitted to the operating room or ICU/CCU of the receiving hospital. Of 62 group II patients, 12 (19.3%) failed to survive ICU.

The ROC curve for RSTP is shown in fig 1. The discrimination power of RSTP AUC was acceptable (AUC 0.743; SE 0.0635; $p < 0.001$; 95% confidence interval 0.619 to 0.868). Table 6 shows predictive values of the RSTP calculated at the cutoff point originally proposed (≥ 7) and at the cutoff point giving the best Youden index (≥ 8 in our series).

The Hosmer-Lemeshow statistic revealed adequate goodness of fit for RSTP ($\chi^2 = 7389$, $df = 7$, $p = 0.390$). Tables of deciles risk are shown in table 5.

Overall mortality was significantly higher in group II than group I patients (7.5% v 19.3%; $p = 0.025$). However, when considering mortality rates of group I and II ICU admissions (25% v 19.3%) the difference did not reach statistical significance ($p = 0.152$). Although the ICU mortality of group II patients who suffered major complications during transport (12 patients, three deaths; mortality 25%) was higher than that of group II patients in whom no major en route complications were recorded (50 patients, nine deaths; mortality 18%) the difference did not reach statistical significance ($p = 0.291$).

DISCUSSION

Our results confirm those of others that interhospital transport of critically ill patients can be safe if appropriate measures are taken before and during transport.^{1 17–19} No deaths were encountered during transport. Because severe trauma and complicated myocardial infarctions were the most common causes for transport (table 4), shock was the most reasonably expected problem during transfer (table 5). In most cases, this was not really a complication of transfer but rather the reason for it. In four of five trauma patients with shock (patients 3–6, table 5), the reason was penetrating chest trauma necessitating thoracic surgery unavailable in

Table 4 Underlying diseases of patients subjected to interhospital transfer

	Group I	Group II
Adults		
Head trauma/trauma	20 (30.3%)	24 (38.7%)
CVA*	5 (7.57%)	6 (9.67%)
Cardiac disease	6 (9.09%)	16 (25.8%)
Respiratory disease	4 (6.06%)	3 (4.83%)
Other†	8 (12.12%)	4 (6.45%)
Children		
Head trauma	5 (7.57%)	1 (1.61%)
Infections	5 (7.57%)	1 (1.61%)
Other†	2 (3.03%)	2 (3.22%)
Neonates		
Prematures	10 (15.14%)	4 (6.44%)
Other†	1 (1.51%)	1 (1.61%)

*CVA, cerebrovascular accident; †other includes pancreatitis, upper gastrointestinal tract bleeding, burns, neurological, surgical, and obstetric causes.

our hospital. All patients were rapidly transported after chest drainage and endotracheal intubation. Blood and blood substitutes were given en route to keep systolic blood pressure >90 mmHg. The emergency department of the receiving hospital was bypassed in all cases and patients were directed straight to the operating theatre. All patients survived surgery and three of the four survived ICU. Two trauma patients with shock had rapidly expanding epidural haematomas and liver contusions (patients 7 and 9, table 5). They were rapidly transported in the same manner as the previous cases. They also survived the operation and ICU stay. Finally, one patient in cardiogenic shock (as a result of acute myocardial infarction) was transferred for emergency coronary balloon angioplasty.

Shock is difficult to define, evaluate, and treat, and although transported patients must be physiologically stable before transfer, postponing definite care in the presence of an evolving disease such as head trauma or acute coronary syndrome can be fatal or a substantial risk factor for multiple organ failure and intensive care mortality.³ Our practice of rapid transfer under full circulatory support, the strict control by a senior ICU doctor during transfer, the absolute cooperation with the receiving hospital, and the relatively short transfer time resulted in the patients' good outcome.

In contrast to difficulties and arguments about cardiovascular stabilisation before transfer, respiratory support strategies are uniformly accepted and effective in preventing complications en route.²⁰ The adopted practice by our team to intubate before transport all patients suffering from or susceptible to respiratory or CNS deterioration during the trip

Table 5 Major complications during interhospital transfer

Patient no.	Disease	Complication	Age (years)	Sex	Score	Survival
1	CVA*	Hypertension	72	F	5	Yes
2	Premature	Aspiration	0	F	4	Yes
3	Trauma	Shock	20	M	12	Yes
4	Trauma	Shock	19	M	16	Yes
5	Trauma	Shock	75	F	17	No
6	Trauma	Shock	35	M	12	Yes
7	Head trauma*	Shock	36	F	8	Yes
8	Head trauma	Coma	18	M	12	Yes
9	Head trauma*	Shock	19	M	11	Yes
10	Trauma	Shock	56	M	7	No
11	AMI	Shock	65	M	9	Yes
12	AMI	APO	58	M	9	No
13	CVA	Hypertension	59	M	12	Yes
14	CVA	Hypertension	60	M	15	Yes

Numbers in the first columns represent consecutive patients. CVA, cerebrovascular accident; AMI, acute myocardial infarction; APO, acute pulmonary oedema; *Cases 7 and 9 were multitrauma patients.

Figure 1 ROC curve for risk score for transport patients (RSTP).

(72.5% in our group II patients) and the advanced technology of modern portable mechanical ventilators, practically solved the respiratory part of cardiorespiratory support during transfer. Novel therapies for severe oxygenation failure (from ventilation in prone position to extracorporeal membrane oxygenation) have recently made transport over long distances achievable even for patients with severe oxygenation failure.^{17, 18}

Evidence supporting the high quality of the care provided to our patients during transfer (effective management of en route complications), is the non-significant difference between the ICU mortality of those patients who suffered major en route complications versus those who did not. In addition, although not mutually matched in pairs of similar severity, the average mortality rate of transferred patients who required admission to the ICU of the receiving hospital (78 patients, 18 deaths, 23%), was not significantly different from the average mortality of the other patients of the receiving ICU (20%; unpublished data). Similar results have been reported by Surgenor *et al*, who did not find any difference in ICU mortality between patients admitted to ICU after referral from other hospitals and patients admitted to the same ICU from the wards of a tertiary receiving hospital.²¹

The utility of using risk scores for transport patients is controversial, as their principal aim is to limit the number of staff used in transfers. Most of our transfers took place during non-working hours, when specialist transport teams were rarely available. Therefore, patient triage at the time of referral is important. Different indexes of risk of transport have been tested, none of them being widely accepted.^{5, 9, 22, 23} Some authors believe that high quality care during transport will abolish the relationship between severity of illness and risk of complications, and paradoxically, scoring systems may

Table 6 Predictive performance of risk score for transport patients at the cutoff point originally proposed (≥ 7) and at the cutoff point giving the best Youden index (≥ 8)

	Cutoff ≥ 7	Cutoff ≥ 8
Sensitivity	78%	71%
Specificity	65%	73%
Correct classification rate	67%	73%
Positive predictive value	22%	25%
Negative predictive value	96%	95%
Youden index	0.44	0.45
LRPT	2.29	2.71
CI of LRPT	1.58 to 3.33	1.72 to 4.26

LRPT, likelihood ratio of positive test; CI, confidence interval.

Table 7 Deciles risk for Risk Score for Transport Patients

Decile	n	PE	AE	NE	ANE
1	13	0.5	0	12.4	13
2	20	1.0	1	19.0	19
3	21	1.3	1	19.7	20
4	12	0.8	0	11.2	12
5	12	1.0	1	11.0	11
6	15	1.5	3	13.5	12
7	16	2.6	5	13.4	11
8	16	4.1	2	11.9	14
9	3	1.1	1	1.9	2

PE, predicted en route events; AE, actual en route events; NE, no en route events predicted; ANE, actual no en route events.

therefore only be of value in predicting the risk of inexpert transfer.²³

In this study, the RSTP had acceptable discrimination value and adequate goodness-of-fit in predicting major en route complications. Increasing the cutoff value (from ≥ 7 to ≥ 8) further increased specificity, correct classification rate, PPV, and LRPT, although at the cost of some small loss in sensitivity. The ROC curves provide a complete view of the accuracy of the prognostic scores under study and permit direct comparison of the AUC obtained for various prognostic scores.^{12, 13} Although it can be stated that AUC and overall accuracy of prediction are less useful tools for evaluation of a risk score in critically ill patients (because when transferring such patients, missing one severe en route complication is potentially more disastrous than correctly predicting the majority of the more numerous transfers without complications), we strongly believe that its high negative predictive value precludes the aforementioned argument. Finally, the RSTP had also a LRPT high enough to generate as previously mentioned small but sometimes important changes in probability.

This study has the major result that RSTP has a correlation with the outcome of the patients as well as the complications observed during the transport. Despite initial stabilisation and meticulous follow up during transport, group II patients were more severely ill than group I patients, thus they had a higher RSTP. It seems that if major en route complications are effectively and on time managed, the prognosis depends not on the 60 minute transfer delay but on the severity of the underlying condition, which is properly reflected on the RSTP. However, our primary objective was to validate the performance of the RSTP in predicting patients most likely to develop major complications during interhospital transport. Thus, the performance of RSTP in predicting long term mortality was not validated in terms of discrimination and calibration.

CONCLUSIONS

Interhospital transport of critically ill patients can be safe in the hands of experts. Shock remains the most common problem encountered during transport. The RSTP seems effective in differentiating critically ill patients prone to develop major en route complications. Further studies with larger numbers of patients are however required to confirm its applicability and to define its optimal cutoff value.

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