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Original Article

Scoring system for activation of critical care air transport team for aeromedical evacuation

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ABSTRACT

Background: Our hospital began work on formulating its own critical care air transport team (CCATT) and patient transfer unit (PTU) in 2007. A total of 293 patients have been evacuated by air using the various models of the PTU from April 2008 to February 2017. This study has been undertaken to formulate a protocol for activation of CCATT for aeromedical evacuation that best suits our setup keeping in view the availability of electromedical equipment, manpower and aircrafts.

Methods: The study is a cross-sectional study involving patients who were air evacuated between January 2010 to February 2017. Statistical analysis tests were performed to compare and analyze the two scoring systems to find out the sensitivity and specificity of the two scoring systems and to find out the degree of agreement.

Results: The data using each scoring system were compared with actual requirement of CCATT based on recommendation of team leader of each CCATT mission and available data of each patient. It was observed that the old scoring system showed poor agreement with kappa coefficient of 0.162. The new scoring system based on modified early warning physiological score showed good agreement with kappa coefficient of 0.895.

Conclusion: CCATT can be activated by peripheral medical echelons based on objective criteria rather than subjective ones so that optimal use of resources can be carried out not only in peace time but also during mass casualty scenarios such as natural calamities or war.

Introduction

Aeromedical evacuation (AE) of combat casualties has its roots deeply embedded in military history. Over the last century, it has gradually evolved from using aircrafts of opportunity with no caregiver in-flight or medical equipment on board to providing critical care in the air with miniature, portable, airworthy equipment using specially trained teams in an aircraft reconfigured for aeromedical evacuation.[1]

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The American Armed forces are the pioneers in long distance AE. They launched the critical care air transport program in 1994, which enabled them to perform intercontinental aeromedical evacuations using specialized teams—The critical care air transport team (CCATT).[2] The British have their own version—The Critical Care Air Support Team[3] as do most Armed Forces of developed countries.

The Armed Forces of our country, in contrast, while having a protocol for AE of mass casualties who are stable, do not have one for AE of the critically ill. The Army and paramilitary forces have been fighting terror and insurgency at the country's borders. The operations typically involve short bursts of high intensity conflicts in inhospitable terrain with poor road and rail connectivity with the zonal and Command hospitals which are located at a fair distance away. In addition, troops stationed in remote areas may require time-sensitive advanced investigations or medical management, which are not available in field hospitals. This small subset of the critically ill, require AE with in-flight monitoring and treatment to achieve a favorable outcome.

Our hospital began work on formulating its own CCATT and patient transfer unit (PTU) in 2007. A total of 293 patients have been evacuated by air using the various models of the PTU from April 2008 to February 2017.

Types of peacetime AE undertaken in the sector of our operations:

1) Elective AE:

It is the air evacuation of patients who are stable and in a convalescent phase of their disease or injury course. Patients are air evacuated to a higher medical facility if a particular investigation/therapeutic intervention or expertise is not available in the vicinity. Examples: Non-ST elevation acute coronary syndrome transferred to cardiac center for coronary angiography after initial management, stable dorsolumbar vertebral fracture without neurological deficit and open comminuted long bone fractures after initial stabilization for transfer to orthopedic center.

2) Urgent:

It is the air transport of a stabilized patient rather than a stable patient within 48 h of onset of disease or injury after treatment has been instituted which is adequate to assure the movement to definitive care without adverse sequelae. The patient has assured airway, stabilized fractures, all haemorrhages are controlled and patients are fluid resuscitated. Examples: Patient with severe head injury/cerebrovascular accident status after external ventricular drain or decompressive craniectomy, polytrauma after initial damage control surgery or severe acute pancreatitis with multiorgan dysfunction syndrome, requiring dialysis or critical care management.

3) Emergent AE:

It is the air transport of a potentially unstable patient to save life or limb primarily because necessary medical facilities or personnel are not available locally. Examples: Concealed ongoing hemorrhage not controlled by conservative measures or by conventional surgical procedure, requiring services of interventional radiologist, dissecting aortic aneurysm requiring intervention at a Cardio-Thoracic Vascular Center or ST elevation acute coronary syndrome with failed thrombolysis for emergency PCI/CABG at a cardiac center.

Different aeromedical teams follow different protocols to evaluate the critically ill patients.[5,6] This study has been undertaken to formulate a protocol that best suits our setup keeping in view the availability of electromedical equipment, manpower and aircrafts not only in peace time but also during mass casualty scenarios like natural calamities or war.

Materials and methods

The study is a cross-sectional study involving patients who were air evacuated between January 2010 to February 2017 using CCATT or air transport team (ATT). CCATT comprised six members which included one anesthesiologist, nursing officer, operation room assistant (ORA), house-keeping member each and two medical assistants. The composition of ATT lacked the presence of anesthesiologist.

Data was recorded in a specific format by the team leader of each aeromedical evacuation mission. The data were being maintained at the Department of Anesthesiology and Critical Care in hard copy, as well as soft copy in excel format. The data of each mission recorded by the respective team leader was cross-checked by the Head of the Department of Anesthesiology & Critical Care and finally put up to the Head of Institution for approval.

The data recorded included patient details, date and time of transfer, total flying time, diagnosis and case summary, physiological parameters, total score as per old, as well as new scoring system, in flight medical management and interventions performed, medical and administrative difficulties faced and specific recommendations of the team leader to overcome those difficulties. The physiological parameters were noted before the PTU boarded the aircraft, during the flight and just before handing over the patient to the receiving team of the hospital, where the patient was being air evacuated. The parameters were noted by the ORA detailed to accompany the patient under the supervision of the team leader. A copy of the recorded data was handed over to the receiving team as handing/taking over notes for their reference. The team leader was detailed on rotation basis from the anesthesiologists who were posted to our hospital from time to time. At any given time, two to three anesthesiologists were posted to our department, and all performed the duties of team leader after familiarization with the standard operating procedure (SOP) of aeromedical evacuation by CCATT. All missions were being conducted under the supervision of Officer in charge of PTU who was the second senior most anesthesiologist of the department who in turn reported to the Head of the Department. Regular training classes with simulations and practical demonstrations are being conducted in the department so that all team members are well versed with the SOP.

The original scoring system for evaluating severity of casualties for deploying of CCATT was a very detailed one with a

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Table 1 – The original scoring system for evaluating severity of casualties for activation of CCATT.

S. no	Clinical condition	Score
1.	Nature of illness	
	(a) Priority III	1
	(b) Priority II	2
	(c) Priority I	3
2.	Hemodynamic stability	
	(a) Stable	0
	(b) Stable with fluid resuscitation/inotropes	1
	(c) Unstable	2
3.	Airway integrity	
	(a) Airway uncompromised	0
	(b) Airway compromised	
	(i) Secured with oro-pharyngeal/nasopharyngeal airways	1
	(ii) Supraglottic devices	2
	(iii) Intubation/Tracheostomy	3
4.	Requirement of oxygenation	
	(a) No Oxygen supplementation	0
	(b) Oxygen supplement at low FiO_2 (≤40%)	1
	(c) Oxygen supplement at high FiO_2 (>40%)	2
	(d) On ventilator	3
5.	Chest injuries	
	(a) No chest injuries	0
	(b) No active intervention	1
	(c) Chest tube in place	2
	(d) Flail chest/Perforating chest injuries	3
6.	Risk of ongoing hemorrhage	
	(a) No haemorrhage	0
	(b) Bleeding controlled with pressure bandage	1
	(c) Retracted bleeders	2
	(d) Concealed haemorrhage	3
7.	Central Nervous System	
	(a) No injuries	0
	(b) GCS > 13	1
	(c) GCS 9-12	2
	(d) GCS < 8	3
	Total	-/20

Total maximum scoring points: 20.
Definite requirement of CCATT: ≥ 12/20.
Air Transport Team (ATT) without CCATT: 9–12/20.
CCATT, critical care air transport team.

large list of priority I and II cases. So, the efforts were made to simplify the scoring system to be based on the concept of modified early warning scoring systems using physiological parameters such as heart rate, systolic blood pressure, respiratory rate, temperature, CNS examination, SpO_2, and oxygen requirements. Statistical analysis tests were performed to compare and analyze the two scoring systems to find out the sensitivity and specificity of the two scoring systems and to find out the degree of agreement.

The data using each scoring system were compared with actual requirement of CCATT based on recommendation of team leader of each CCATT mission and available data of each patient.

Results

The study is a cross-sectional study involving 230 patients who were air evacuated between January 2010 to February 2017. Although the CCATT programme was started in 2007, the data of patients evacuated between 2007 and December 2009 were not available (about 63 patients). Data were available for a total of 230 patients from January 2010 onward till February 2017.

Of the total number of patients who underwent AE, about 61% belonged to the Army, 16% to Para-military forces, 10% to Air Force, and about 4% to Territorial Army. Even AE of few families (10 patients), Defense civilians (2 patients) and one veteran were carried out.

About 31% (70/230) patients were transferred on mechanical ventilator including one patient on non-invasive ventilator (Table 3). Two patients were evacuated after tracheostomy with oxygen through a T-piece. Twenty-two patients (9%) were on vasopressor/inotropic infusions support enroute (Table 3). Of these, 16 patients were on single vasopressor/inotropic infusion and 6 patients required two infusions to maintain the blood pressure. Of these 22 patients, 18 patients were on mechanical ventilator, as well as vasopressor/inotropic support.

A total of 121 (52%) patients were given in flight oxygen therapy. These included patients on mechanical ventilator (70/121) and patients who received oxygen through face mask

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Table 2 – New scoring system based on physiological modified early warning score for activation of CCATT.

S. no	Parameter	3	2	1	0	1	2	3
1.	HR		<40	40–50	51–100	101–110	111–129	>130
2.	Systolic BP	<70 or on vasopressors	71–80	81–100	101–170	171–199	>200	
3.	Resp rate	On Ventilator	<7		9–18	19–22	23–29	>30
4.	Temp (°F)	≤94.8	95	95.2–96	96.2–101	101.2–102	102.2–103	>103
5.	CNS	Acute focal deficit	New confusion, agitation		Alert	Voice	Pain	Unresponsive
6.	O_2 requirement				Air			Any O_2
7.	SpO_2	<91	92–93	94–95	≥96			

New Scoring system for AE.
- Score: 0–2: Elective evacuation with minimal manpower.
- Score 3–5: Urgent evacuation with Air Transport Team (ATT).
- Score≥ 6: Urgent/Emergent evacuation with CCAT Team.

CCATT, critical care air transport team; AE, aeromedical evacuation.

Table 3 – Critically ill patients evacuated.

S. no	In flight interventions	Number
1.	Mechanical ventilator	72
2.	Vasopressor/Inotropic support	22
3.	Mechanical ventilator with vasopressors	18
4.	Oxygen therapy	121

Table 4 – Comparison of CCATT requirement as per old severity score and decision by team leader.

CCATT required as per Old severity score	CCAT requirement as per team leader		Total
	Yes	No	
12 and above	17	88	**105**
9–12	0	105	**105**
Total	**17**	**193**	**210**

Sensitivity 100.00% (80.49%–100.00%).
Specificity 54.40% (47.10%–61.57%).
CCATT, critical care air transport team.

Table 5 – Comparison of CCATT requirement as per new system score and decision by team leader.

CCATT required as per New system	CCATT requirement as per team leader		Total
	Yes	No	
≥6	102	3	**105**
<6	8	97	**105**
Total	**110**	**100**	**210**

Sensitivity 92.73% (86.17%–96.81%).
Specificity 97.00% (91.48%–99.38%).
CCATT, critical care air transport team.

or T-piece (51/121). These were the most sick of all patients who posed the maximum challenge to the team in flight. Data related to hypoxia were not available for about 20 patients and were not included in data analysis.

The data using each scoring system have been compared with actual requirement of CCATT based on recommendation of team leader of each CCATT mission and available data of each patient. It is observed that the old scoring system shows poor agreement with kappa coefficient of 0.162. The old scoring system has a sensitivity of 100% but specificity is only 54% (Table 4). The new scoring system based on modified early warning physiological score shows good agreement with kappa coefficient of 0.895. The new scoring system has a sensitivity of 97% and specificity of 92% (Table 5).

Discussion

There has been a significant improvement in survival of combat casualties in recent years owing to advances in concepts of damage control surgeries, better care after initial resuscitation, and providing advanced in-flight care during aeromedical evacuation of casualties. These principles have been used successfully by US Air Force in developing CCATTs for AEs of critically ill casualties from combat area to hospitals with advanced facilities.[2] Same principles of care can be applied for AEs of critically ill from forward bases of Armed Forces during peace time or during mass casualty scenarios such as natural disasters, allowing them to reach higher medical echelons in least possible time.

The PTU at our hospital was indigenously fabricated, and the CCATT was formed with the express intention of evacuating critically ill stabilized (but potentially unstable) patients from remote areas of the north-east to a zonal hospital in the eastern sector or a Tertiary care Hospital in Kolkata, Guwahati or New Delhi while monitoring the patient continuously in flight, performing on-board interventions if necessary and ensuring that the austere, hypobaric flight environment did not affect the patient's condition.

Requisition for AE by CCATTT

Most of the AE by CCATT involved Army personnel (61%) in this study. The Army peripheral hospital put in a request for AE to HQ Air Command through Army channel. The decision for AE with CCATT is taken by the treating doctor of the peripheral hospital and the CCATT leader is neither consulted for the requirement of CCATT for AE nor briefed about the details and current condition of the patient by the treating

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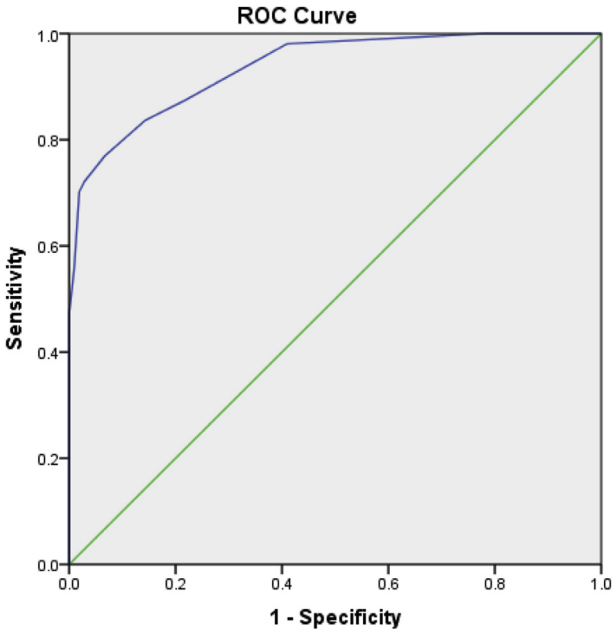

Fig. 1 – ROC curve of old score with CCATT requirement (gold standard). At cut off score of 12 sensitivity is 100% but specificity is 54%, Area under curve is 0.934 (0.904–0.965). CCATT, critical care air transport team.

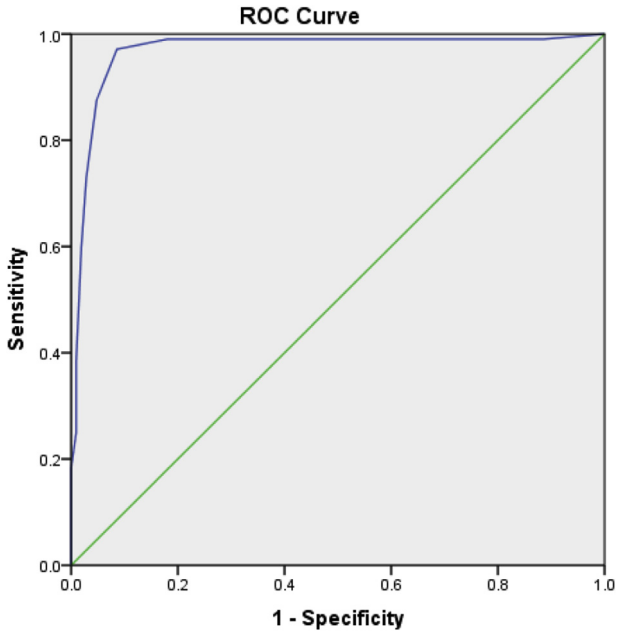

Fig. 2 – ROC curve of new score with CCATT requirement (gold standard). At cut off score of 6 sensitivity 92% and specificity is 97%, Area under curve is 0.969 (0.943–0.995). CCATT, critical care air transport team.

doctor. The CCATT takes over the patient on the tarmac of the airfield closest to the military hospital and therefore does not participate actively in patient preparation for AE which is of vital importance. The CCATT leader also cannot brief the treating physician regarding the patient's preparation for AE before the patient is moved to the airfield by the personnel of the treating hospital because of poor interservices communication network. In addition, the scoring system for accessing severity of the disease or trauma and need for deployment of the CCATT is not available at the peripheral hospital and the CCATT in most instances is deployed based on a 'felt' need rather than laid down objective criteria.

The new scoring system used in our study is a modification of various early warning physiological scoring systems used for patients admitted in hospitals in various countries.[4] These physiological early warning systems have been developed to recognize the early signs of clinical deterioration in the patients admitted in hospitals, so that early intervention and management can be initiated in the form of increasing nursing attention, informing the physician or activation of a rapid response team or a medical emergency team. Adopting an early warning physiological scoring system in a hospital setting has proven to be beneficial for standardizing the assessment of acute illness severity, enabling a timely response using a common language across acute hospitals.

This scoring system was modified in our study to be used at the time of assessment of the patient being planned for air evacuation. A cutoff score of $\geq$6 of a total score of 21 means that the patient is sick enough to warrant intensive monitoring and treatment inflight by the CCAT team. This is considered to be the cutoff for activating the CCATT for urgent or emergent AE. A score of 3–5 means that the patient is stable but requires monitoring more than that is considered for elective AE. It is considered to be the cutoff for activating the ATT for an urgent AE. A score of 0–2 means the patient is stable and unlikely to deteriorate in flight owing to the patient's condition or rigor of aeromedical evacuation. This score is considered to plan an elective AE without activation of ATT/CCATT. Similar score of Modified Early Warning Score is used by the Intensive care Society of UK for transport of the critically ill adults[5] and by Royal Doctors Service of Australia Western Operations (MET) criteria.[6]

By analyzing the two scoring systems used in the study, it has been observed that the old scoring system is not only a very detailed one with a long list of priority I and II cases but also has a sensitivity of 100% and specificity of 54% at a cutoff score of 12 of 20 with Kappa coefficient of 0.162, indicating poor agreement with AUC 0.934 (0.904–0.965) when it was compared with the need for activation of CCATT as per CCATT leader recommendations, as well as based on the available data (Tables 1 and 4, Fig. 1).

The new scoring system fares better at a cutoff score of 6 of 21, the sensitivity is 92% and specificity is 97% with AUC 0.969 (0.943–0.995). Kappa coefficient is 0.895 indicating good agreement when it was compared with the need for activation of CCATT as per CCATT leader recommendations, as well as based on the available data (Tables 2 and 5, Fig. 2).

Twenty patients of 230 were not included in evaluation of scoring system as these patients belonged to the category of elective AE and did not require CCATT/ATT for their transfer. They were transferred along with patients for whom CCATT/ATT was activated as a matter of convenience.

As majority of patients undergoing AE are adult serving armed forces personnel, this scoring system is suitable for adult patients. For AE of pediatric patients, this scoring system needs to be modified further based on pediatric early warning

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scoring system respectively, as physiological parameters cutoff limits of the pediatric age groups are different, based on their age.[7]

Limitation of the study is that no gold standard criteria exist to which the scoring system can be compared. It is a cross-sectional study and subject to reporting bias owing to inaccuracies in recording of data. Patients with severe illness tend to have more complete records as compared with stable patients. The teams recording the data have not been trained in aeromedical transportation of critically ill. That may be a source of bias. Another source of bias may be information bias as some data may get lost if a disability is coexisting with a more severe one. The data related to less severe disability might be missed or underreported. Further studies will be required to validate this scoring system for use in activation of CCATT.

Conclusion

The concept of CCATT was started at our hospital, so that majority of our fighting soldiers and their families can be provided with best of medical facilities at shortest possible time even when they are located at far flung areas with limited resources. It is time to take the concept to the next level, where CCATT can be activated by peripheral medical echelons based on objective criteria rather than subjective ones so that optimal use of resources can be carried out not only in peace time but also during mass casualty scenarios such as natural calamities and war.

Conflicts of interest

The authors have none to declare.

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