Validation of Prehospital Predictor of Macroaspiration at Trauma Site Score: Correlating with Mortality following Severe Aspiration Pneumonia

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Abstract

Introduction Predictor of macroaspiration at trauma site (PMAT) scoring was introduced to assess the role of early interventions including check bronchoscopy in improving the outcome of patients with severe brain injury. This article presents the statistical evaluation of the scoring method and suggests modifications of the same for further applications.

Materials and Methods Data of 67 patients treated by the authors were evaluated with statistical tools with the objective of predicting macroaspiration and mortality due to pneumonia following severe traumatic brain injury. Fisher exact test was employed to study relationship between PMAT scores and finding of macroaspirate on bronchoscopy.

Results Mean PMAT scores among those who died due to pneumonia versus those who did not die were compared. Mean PMAT scores were higher among those who died due to pneumonia (10.43 vs. 9.60) but not significantly higher ($p = 0.181$). When PMAT score was categorized into low or high (low for scores less than 9 and high for scores 9 and above) and a chi-square test was applied, the results were significant, that is, those with high PMAT score have higher risk of death due to pneumonia. With the present data, the score failed the internal validation test to predict a macroaspiration event alone.

Conclusion The PMAT appears to be valid with regard to its predictability of high risk of death due to pneumonia or in other words, the severity of aspiration pneumonia. The study suggests a pilot guideline for future similar studies to categorize the study groups according to the score and assess possible adverse outcome. The shortcomings of the study include single investigator, single-center study, small sample size, and absence of a valid guideline to begin with. Future studies will need to address these issues.

Keywords
- aspiration pneumonia
- brain injury
- PMAT score
- rural India

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Introduction

The management of traumatic brain injury has made leaps of progress with regard to survival and recovery. In resource-rich settings, the survival of severe traumatic brain injury is reaching near certainty. However, in a large part of the world particularly in most low- and middle-income countries, the reality remains very different. Infrastructure for primary care of patients with traumatic brain injury and associated polytrauma continues to remain inadequate. In rural and semirural India, where one of the authors works, minimum estimated time to report to the only neurosurgical unit is usually 4 to 5 hours. Transfer from long distance is met with delays of 7 to 12 hours that are not only transport related but also of social nature (decision to seek health care, affordability, etc.) Suboptimal equipment for transport and lack of trained human resource and materials complicate the injury. This "secondary insult" results in adverse outcomes both with regard to survival and the complication associated with prolonged period of therapy. Macroaspirate, one such secondary insult, has been associated with greater extent of inflammation in animal studies. Its role in humans is intuitive and yet remains to be proven. In resource-limited settings, where bronchoscopy may not be available or affordable, it is pertinent to develop predictive criteria relevant in rural India settings for patients who are likely to have developed macroaspirate. This article presents the pilot application of a scoring system in rural India setup.

Materials and Methods

The study includes patients of severe brain injury managed in a single institute during the period of 2010 to April 2014. All patients were deeply comatose with Glasgow coma scale (GCS) score of 8 or less either directly brought to the center or primarily managed at another center. The protocol involved primary assessment of patient for polytrauma including thoracic injury. Exclusion criteria included those with thoracic injury, age younger than 18 years or older than 60 years, associated diabetes mellitus and chronic obstructive pulmonary disease or other chronic pulmonary illness and patient not requiring intubation and ventilation (►**Table 1**). Patients who satisfied the inclusion criteria were then screened for presence of maxilla-facial injury, skull base injury, and cerebrospinal fluid (CSF) rhinorrhea. Considering the available resources in the semirural and rural section of India where this study was conducted, an attempt to predict the population who are likely to have macroaspirated was made by the use of a self-developed scoring system (►**Table 2**). The predictor of macroaspiration at trauma site (PMAT) score defines multiple parameters which are crucial in airway protection. The score ranged from – 3 to 23. Score above 6 was considered to have significant bolus of aspiration to warrant a check bronchoscopy and of the 67 patients, 40 candidates who reached or could be stabilized in the unit within 6 hours of trauma underwent the procedure. Such a lower limit was purely matter of choice based on the clinical presentation of our study cohort. The PMAT data were collected soon after stabilization of the patient by the author during interview with the relative or the accompanying people.

Patients underwent the procedure after stabilization with ventilator support using an Olympus BF type P10 bronchoscope. Macroaspirate was defined when either gross particulate material was observed including clots in the bronchial airway or if the aspirate lavage fluid showed presence of particulate material. The findings were noted with regard to the extent of particulate matter, blood products, and inflammation in the tracheobronchial tree. In all cases, a bronchial lavage with normal saline was given using 15 to 20 mL total lavage volume. Outcome measures of the study included presence of pneumonia on day 7 and survival at 3 weeks. Swabs from endotracheal tube were taken on day 4 from all patients. Stringent bronchoscope sterilization procedures were maintained before and after each procedure.

The PMAT data and the outcome of the patients were reviewed. The PMAT score was cross tabulated with the finding of macroaspiration, pneumonia, and death due to pneumonia. This was subjected to appropriate statistical evaluation. To study relationship between PMAT scores and finding of macroaspirate on bronchoscopy, Fisher exact test was employed.

Predictor of Macroaspiration at Trauma Site Score Criteria

The criteria chosen were based on the personal experience and the mentioned important factors affecting the severity of injury and triage methods as mentioned in Indian and international studies.

Table 1 Patient selection criteria

	Inclusion criteria	Exclusion criteria
1	GCS < 8	GCS > 8
2	Altered sensorium due to road traffic injury	Associated thoracic injury
3	Age > 18 y and < 60 y	Pre-existing pulmonary disease (COPD, tuberculosis, etc.)
4	Patients requiring intubation and ventilation	Diabetes mellitus
5	PMAT score > 6	Associated spine injury

Abbreviations: COPD, chronic obstructive pulmonary disease; GCS, Glasgow coma scale; PMAT, predictor of macroaspiration at trauma site.

Table 2 Predictors of macroaspiration at trauma site

		Allotted score	Patient score for example
Type of trauma (at least 1)	High velocity (> 40 km/h Indian roads)	1	0
	Tangential or rotational injury	1	1
	Thrown out or off vehicle	1	0
GCS	5–8 (1 point) or < 5 (2 points)	1 or 2	2
Extent of injury (at least 1)	Maxilla-facial injury	2	2
	Fracture mandible	2	2
	Decerebrate posturing	2	0
	Quadriplegia	1	0
	CSF rhinorrhea	2	0
	Convulsions	2	0
Primary triage care	Vomiting during transport	2	2
	Suspected aspiration during transport	2	2
	Intubated	−2	0
	Hypovolemic shock managed	−2	0
Under the influence of alcohol	Alcohol in vomitus	2	0
Rescue team	Untrained citizen/trained citizen	1/ − 1	1
Transport team	Untrained ambulance (1 point) Trained 108 service (−1 point)	1/ − 1	1
Total score			(13)/23

Abbreviations: CSF, cerebrospinal fluid; GCS, Glasgow coma scale.
Note: Greater the score, higher is the chance of macroaspiration. Maximum score being 23 and minimum being −3. In the present study, all patients were placed between 6 and 24.

1. *Type of trauma*: this section included the following three criteria:
   a. *Assumed velocity of impact*: As measured by direct or indirect methods. Direct method used data on the velocity of vehicle preceding the impact as reported by care-givers of patient. Indirect evidence included impact into the vehicle or observations of on-site citizen were noted. The reliability of such indirect evidence is low but correlated well with the severity of the brain injury in most cases. Any net velocity of impact greater than 40 km/h was considered significant based on automobile velocity impact studies.[1] No Indian studies were found which commented on any form of velocity of vehicles having road traffic accidents on Indian roads.[2–5]
   b. *Tangential or roll over injuries*: These injuries are known to cause diffuse axonal injury and associated deep coma predisposes patients to early aspiration. The primary mechanism based on angular acceleration is a combination of rotational motion and translation acceleration resulting in deep-seated injury.[6] This results in quick and lasting alteration of sensorium.
   c. *Thrown off the vehicle*: It has direct correlation to the severity of injury.[7,8] This is very relevant to areas of local roads which are gyrating and often with unexpected potholes. Another problem peculiar to the region is the presence of cattle and stray dogs on roads causing collision and fall from motorcycle where the pillion rider has been thrown off the vehicle.
2. *GCS score*: This is well established for its predictability of the extent of injury to the brain,[9] and therefore, the possibility of aspiration. Vomiting and pooling of gastric contents were noted to be greater in the group with GCS score of 5 to 8.
3. *Extent of injury*: It is related to the injury to the head and face which could in addition increase the chance of aspiration. They included:
   a. *Maxilla-facial injury*: Massive hemorrhage is known to occur in case of such injuries. Blood pooling often flood the airway along with oral contents.[10–12]
   b. Fracture of mandible causes difficulty in swallowing and internal hemorrhage. If associated with retching and vomiting, it may predispose to macroaspiration.
   c. Decerebrate posturing particularly during transport when the patients may not be appropriately handled, caused severe abdominal contraction, and breathe holding followed by deep inspiration—a sequence which is likely to cause aspiration. Literature search did not reveal any published literature on this issue. This criterion was taken from the personal experience of the author.

d. *CSF rhinorrhea*: This condition after skull base fracture is a potential event and is often associated with severe pooling in the oropharynx and aspiration in a patient with altered sensorium. The author has observed the presence of small clots at the level of secondary and tertiary level bronchioles in patients with severe CSF rhinorrhea. This could probably be explained by the lesser coagulability of the blood in the presence of the CSF in the oropharynx and resultant entry into the airway. As the CSF filters away into the distal airway, the constituent blood settles and forms plugs in the intermediate airway. No related literature was available.
e. *Convulsions*: Seizures will result in deterioration in sensorium of the patient and permit greater aspiration.[13] In addition, due to the persistent tonic state due to the seizure, patient develops increased intraabdominal pressure resulting in large volume vomit. This increases the macrocontent of the aspirate.

4. Primary triage care includes:
   a. Vomiting during transport in patients with altered sensorium is more likely to cause aspiration particularly if there is inadequate oral suctioning facilities in the transport vehicle.
   b. Suspected aspiration during transport: It is occasionally reported by relatives or the paramedic as sudden choking and respiratory distress followed by vigorous coughing by patient. Suspected aspiration unless otherwise proved is an indication of aspiration of orogastric contents into the airway. In the Indian scenario in which the author has worked, common citizens are often able to report the incident from their observations.
   c. Intubated early at a primary care center, especially when the transport distance is long, can prevent the incidence of aspiration of orogastric contents. The area in which the authors conducted the study, the pattern of on-site management, remains "pick and run" of the organized prehospital care.
   d. Management of hypovolemic shock can prevent a depressed cough reflex and in general, the patients' sensorium from further deteriorating into deeper coma and thereby prevents aspiration.
5. *Under the influence of alcohol*: Patients' sensorium is altered further due to the trauma and the regurgitated vomitus may cause a form of nasopharyngeal anesthesia resulting in decrease in the laryngopharyngeal reflex. This predisposes to greater aspiration of both macrocontents and volume.
6. *Rescue team*: Maybe untrained or trained citizen. This could be one of the single most challenging aspects in community management. In spite of efforts directed at citizen training, the general change at the ground level is far from ideal. Though the intensions are for the best, lack of knowledge and nonavailability of resource make primary rescue operations the weakest point in securing the airway. It was observed that once the patients were handed over to the trained paramedics, a basic protocol of handling patients was followed.
7. *Transport team*: In general, India lacks good transport service. At village level, the best transport may be a three wheeler motor vehicle or a very basic four wheeler which transport patients over great distances. They lack proper stretcher, head supports, or restrictors. Suction equipment are absent in most cases and patients are brought unmonitored. The government has recently introduced on-call ambulance popularly known as "108 ambulances." Although few in number, these ambulances do cater to most of the basic requirements necessary for safe transport of patients.

Analytical Approach

Mean PMAT score of those who died of pneumonia was compared with mean PMAT score of rest of the patients using unpaired *t*-test. However, the probability of aspiration and consequent pneumonia is likely to be very high beyond a certain PMAT score. Hence, the PMAT score was divided into low score (8 and below) and high score (9 and above). With no previous literature on the issue, the cutoff value of 8 was arbitrarily decided as it corresponded to lowest quartile of sample. Deaths due to pneumonia were then compared between low and high PMAT score groups using chi-square test.

Results

A total of 67 patients fulfilled criteria for inclusion in the study. PMAT scores were calculated for all patients and are presented in ►**Table 3**. Nearly three-fourths had score of 8 and above and was termed as high PMAT score; the overall range was from 3 to 17. A total of 14 patients died due to pneumonia and mean PMAT scores among these patients were higher than among remaining patients, but the difference in means was not significant (►**Table 4**). There was no pneumonia death in the low PMAT score group, whereas there were 14 deaths in high PMAT score group (►**Table 5**). Results of bivariate analysis (chi-square test) showed that risk of death due to pneumonia was significantly higher among those with PMAT scores of 9 and above. Bronchoscopy could be possible in 40 of these patients. With regard to the PMAT score compared with observed macroaspiration, the results (►**Table 6**) show that although the proportion of those with macroaspirate decreased with increasing PMAT scores, the difference was not statistically significant. The table shows that patients who scored least on PMAT score did have aspiration.

Table 3 Distribution of patients according to PMAT scores

PMAT scores		Number	Percentage
Low score	8 or below	17	25.4
High score	9–10	23	34.3
	11–12	17	25.4
	13 and above	10	14.9

Abbreviation: PMAT, predictor of macroaspiration at trauma site.

Table 4 PMAT scores among patients who died of pneumonia and others

	N	Mean PMAT score (SD)	*p*-Value[a]
Patients who died of pneumonia	14	10.4 (1.6)	0.181
Patients who died due to other causes and those who survived	53	9.6 (3.1)	

Abbreviations: PMAT, predictor of macroaspiration at trauma site; SD, standard deviation.
[a]Unpaired *t*-test.

Table 5 Relationship between high PMAT scores and risk of death due to pneumonia

PMAT scores	Deaths due to pneumonia Number (%)	No death due to pneumonia Number (%)	Total
Low score (8 and below)	0 (0.0)	17 (100.0)	17
High score (9 and above)	14 (28.0)	36 (72.0)	50
Total	14	53	67

Abbreviation: PMAT, predictor of macroaspiration at trauma site.
Note: Chi-square test (chi-square value = 6.01, $df = 1$, $p = 0.014$).

Table 6 Relation between PMAT scores and observed aspiration on bronchoscopy ($N = 40$)

PMAT scores		Aspiration present Number (%)	No aspiration Number (%)
Low score	8 or below	5 (71.4)	2 (28.6)
High score	9–10	9 (75.0)	3 (25.0)
	11–12	10 (83.3)	2 (16.7)
	13 and above	8 (88.9)	1 (11.1)

Abbreviation: PMAT, predictor of macroaspiration at trauma site.
Note: Fisher exact test ($p = 0.61$).

Threshold (below 9) misses three-fourths of those who did not have aspiration resulting in poor specificity. Our analysis found that increasing the threshold to 9 on PMAT score will miss more than 40% resulting in poor sensitivity (not shown in table). Thus, PMAT score is not appropriate for predicting aspiration. Association of individual variables with aspiration was studied using chi-square test but none of the variable (singly) was associated with aspiration. Cronbach α was estimated for the PMAT score, but the scale was found to be poor (0.131) in internal consistency.

Other Findings

Most patients transported to this unit did not have the facility of in-transport airway securing or suctioning equipment. Local Samaritans were poorly trained in handling an unconscious patient. Instead it was frequently noted that once patient has vomited, he or she is likely to be handled even lesser. All intubated patients were at the first primary care unit that they reached before reaching the neurosurgical unit.

Discussion

It is undeniable that a large part of mortality following severe brain injury alone is due to severe aspiration pneumonia.[14,15] Standard trauma management practice on receiving a patient of severe brain injury (GCS score of 8 or less) involves intubation, early careful Ryle tube insertion, and emptying gastric contents as well as administering antacids. Prevention of aspiration by early securing the airway has proven to be very effective in preventing not only mortality but also decreasing the morbidity and associated huge financial burden. In addition, advanced trauma triage systems have delivered good results in countries or areas with very effective trauma response teams. In areas of the world where this form of scientific triage and on-field institution of therapy is not possible, the incidence of mortality due to severe pneumonitis is very high. In rural India and the network of highways passing through the underdeveloped sections of the countryside, the incidence of aspiration pneumonia continues to be very high. This situation is unlikely to be different in other underdeveloped and developing countries of the world. And yet when it comes to establishing necessary interventions to revert an aspiration-related complication by physical clearance, the debate rages as to the efficiency of the procedures versus the risks involved. As of today, the argument is heavily biased toward the futility of such a procedure. Scientific evidence will be required to convince the need to revisit the issue. And such evidence will involve three aspects—experimental laboratory proof, developing a predictive tool, and clinical

evidence of favorable outcome on implementation of a suggested intervention. Studies on mice have revealed greater degree of inflammation after aspiration of acid and particulate material.[16,17] This is evidence enough suggesting the validity of the proposal in the laboratory with histopathological confirmation. The authors' center has conducted a study in a small cohort of patients, as a pilot evaluation, to assess the feasibility of check bronchoscopy in managing macroaspiration without increasing adversities.[18] Similar conclusions were made by Peerless et al.[19] PMAT score was developed with the rural India resource in mind but its application may be wider with minor modifications. The various rescue and transport-related weak links, both pathophysiological and prehospital triage, were considered.

This study wishes to establish the predictability of macroaspiration after severe brain trauma and the outcome with regard to severity of pneumonia. The statistical data suggest that the present suggested scoring criteria do indeed predict the possibility of death due to severe pneumonia after macroaspiration, and hence, the need to consider early salvage procedure which includes check bronchoscopy among such patients. Though the ability to predict macroaspirate was not statistically significant, it strongly supports the contention that most of the patients of severe brain trauma do aspirate and majority have macroaspirate (as revealed in this study). Hence, there is a need to define a cutoff score above which check bronchoscopic procedure should be encouraged with an intention to prevent severe aspiration pneumonia. Since patients with score greater than 8 and aspiration pneumonia were associated with greater mortality, future studies can begin with a guiding parameter that PMAT score of greater than 8 is an indication for check bronchoscopy and lavage. The scoring system could not assess the severity of macroaspirate and failed an internal validation test to predict macroaspiration alone with a cutoff score of 8 and above.

Modification of the score by readjusting the weights attributed to certain rare occurrence such as CSF rhinorrhea may improve the internal consistency of the test. At the same time, application of the score uniformly to a larger cohort of patient in multiple centers may further help external validation. In spite of certain weakness of the scoring system, the present application can be instrumental in predicting a population of patient who may require aggressive management of the aspirated contents and plan an effective management. The study also emphasizes the need for reconsideration of interventional options in patient with high prediction of macroaspiration.

References

1 Ryan GA. Improving head protection for cyclists, motorcyclists, and car occupants. World J Surg 1992;16(3):398–402

2 Agrawal A, Galwankar S, Kapil V, et al. Epidemiology and clinical characteristics of traumatic brain injuries in a rural setting in Maharashtra, India. 2007-2009. Int J Crit Illn Inj Sci 2012;2(3): 167–171

3 Pruthi N, Ashok M, Kumar VS, Jhavar K, Sampath S, Devi BI. Magnitude of pedestrian head injuries & fatalities in Bangalore, south India: a retrospective study from an apex neurotrauma center. Indian J Med Res 2012;136(6):1039–1043

4 Rastogi D, Meena S, Sharma V, Singh GK. Causality of injury and outcome in patients admitted in a major trauma center in North India. Int J Crit Illn Inj Sci 2014;4(4):298–302

5 Liberman M, Mulder D, Lavoie A, Denis R, Sampalis JS. Multicenter Canadian study of prehospital trauma care. Ann Surg 2003;237(2):153–160

6 Thomas AG, David FM. Mechanism of primary head injury. In: H. W Robert, S. R Setti, eds. Cranial Trauma. Section B of Neurosurgery. 2nd ed. Chap. 259. Vol. 2. New York, NY: McGraw Hill; 1996:2611–2621

7 Fitzharris M, Dandona R, Kumar GA, Dandona L. Crash characteristics and patterns of injury among hospitalized motorised two-wheeled vehicle users in urban India. BMC Public Health 2009;9:11

8 Meena S, Barwar N, Rastogi D, Sharma V. Injuries associated with cycle rickshaws accidents. J Emerg Trauma Shock 2014;7(2): 73–76

9 Dennis AT. Neurological evaluation of a patient with head trauma. In: H. W Robert, S. R Setti, eds. Cranial Trauma. Section B of Neurosurgery. 2nd ed. Chap. 262. Vol 2. New York, NY: McGraw Hill; 1996:2667–2673

10 Gupta B, Prasad A, Ramchandani S, Singhal M, Mathur P. Facing the airway challenges in maxillofacial trauma: a retrospective review of 288 cases at a level i trauma center. Anesth Essays Res 2015;9(1):44–50

11 Krausz AA, El-Naaj IA, Barak M. Maxillofacial trauma patient: coping with the difficult airway. World J Emerg Surg 2009;4:21

12 Lawrence RII. Resuscitation of the multiply injured patient. In: H. W Robert, S. R Setti, eds. Cranial Trauma. Section B of Neurosurgery. 2nd ed. Chap 264. Vol. 2. New York, NY: McGraw Hill; 1996:2689–2695

13 Michael JC, Daniel FK, Ehud S, Donald PB. Intensive management of traumatic brain injury. In: H. W Robert, S. R Setti, eds. Cranial Trauma. Section B of Neurosurgery. 2nd ed. Chap. 265, Vol. 2. New York, NY: McGraw Hill; 1996:2699–2708

14 Fawcett VJ, Warner KJ, Cuschieri J, et al. Pre-hospital aspiration is associated with increased pulmonary complications. Surg Infect (Larchmt) 2015;16(2):159–164

15 Lee A, Festic E, Park PK, et al; United States Critical Illness and Injury Trials Group. Characteristics and outcomes of patients hospitalized following pulmonary aspiration. Chest 2014;146(4): 899–907

16 Raghavendran K, Davidson BA, Mullan BA, et al. Acid and particulate induced aspiration injury in mice: importance of MCP-1. Am J Physiol Lung Cell Mol Physiol 2005;289(1): L134–L143

17 Raghavendran K, Nemzek J, Napolitano LM, Knight PR. Aspiration-induced lung injury. Crit Care Med 2011;39(4): 818–826

18 Chaudhuri PNK. Early bronchoalveolar lavage among patients with severe traumatic brain injury and predicted macro-aspiration. Indian J Neurotrauma. 2015;12(2):111–116

19 Peerless JR, Snow N, Likavec MJ, Pinchak AC, Malangoni MA. The effect of fiberoptic bronchoscopy on cerebral hemodynamics in patients with severe head injury. Chest 1995;108(4):962–965