# Role of Anthropometric Nutritional Assessment in Severe Head Injury

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## Abstract

**Aim** Nutritional demand after traumatic brain injury is increased due to hypermetabolic response. The present study was undertaken to assess nutritional status with anthropometric indices, factors associated, and their prognostic role following severe head injury (SHI).

**Method** A total of 114 patients in age group 20 to 60 years, admitted within 24 hours of SHI, with Glasgow Coma Scale of 4 to 8, and with no serious systemic disorder were enrolled for the study. Of these, 67 were prospectively assessed weekly till 21 days for changes in mid arm circumference (MAC), mid arm muscle circumference (MAMC), and triceps skin fold thickness (TSF). They were studied in relation to other factors and outcome was assessed at 3 months.

**Results** The percentage fall at 3 weeks for MAC, MAMC, and TSF were 14, 10, and 37%, respectively. The percentage of fall in MAMC was the earliest, and was significantly greater in patients with surgical intervention, tracheostomy, prolonged fever, delayed enteral feeding, and greater caloric deficit. Admission MAMC < 90% of standard was significantly associated with unfavorable outcome (odds ratio 5.9 [95% confidence interval 1.3–27.8], $p = 0.01$). Unfavorable outcome was significantly more frequent in patients who had at least 15% fall in MAC (85.7 vs. 41.9%, $p = 0.03$), or 10% fall in MAMC (68.8 vs. 38.2%, $p = 0.04$) at 2 weeks, compared with others. Fall in TSF had no significant association with outcome at 3 months. In multivariate analysis, MAMC fall had significant independent association with unfavorable outcome.

**Conclusion** Bedside anthropometry (especially MAMC) is efficient in identifying patients with nutrition depletion with significant influence on outcome at 3 months.

**Keywords**
- severe head injury
- nutritional assessment
- anthropometry
- outcome

## Introduction

The variety of nutritional and metabolic perturbations following severe head injury (SHI) necessitates aggressive nutritional support in providing the optimal milieu for neurologic and systemic recovery. Despite having numerous indices for the assessment of nutritional status, no objective parameter has been studied till date, to be of value in the nutritional assessment of patients with SHI. Bedside anthropometric measurements have the advantage of being

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objective, rapid, repeatable, noninvasive, and inexpensive in comparison to various biochemical investigations. Anthropometric parameters are reliable estimates of somatic protein reserve which is an early indicator of nutritional depletion.[1]

## Objectives

1. To test the validity of weekly anthropometric monitoring in assessing the nutritional status of patients with SHI.
2. To study the factors associated with progressive fall in anthropometric values.
3. To evaluate the prognostic significance of anthropometric parameters at admission and their changes with respect to functional outcome.

## Methods

Adult patients admitted within 24 hours of SHI under the Department of Neurosurgery, AIIMS, New Delhi, India, from June to December 2005, were enrolled for the study. Patients with age more than 60 years, Glasgow Coma Scale (GCS) of 3, or with any systemic injury or disorder had been excluded.

Standard care given to study patients consisted of ventilation, seizure prophylaxis with phenytoin, antibiotic prophylaxis with cefotaxime or ceftriaxone and netilmicin, and gastric ulcer prophylaxis with ranitidine. Mannitol was given to patients with computed tomography (CT) having evidence of mass effect. Frusemide was added to patients with midline shift. Decision regarding surgical decompression was taken according to the mass effect noted in CT. Enteral feeding was initiated either through nasogastric tube or orally as early as possible and the volume of feed increased gradually according to the gastric tolerance. Patient characteristics, clinicoradiological features, laboratory parameters, mid arm circumference (MAC), triceps skin fold thickness (TSF) at admission, and their weekly changes till 21 days were noted down in a preplanned prospective database and were followed up.

## Mid Arm Muscle Circumference Calculation[2-4]

Nonstretchable inch tape was used to measure MAC (in cm) from the mid-point of the nondominant arm between the acromion and olecranon processes with the forearm flexed at 90 degrees and the mean of three measurements recorded. TSF (in mm) was noted from the mean of three measurements taken with McGay caliper applied over a pinch of skin and subcutaneous fat around the same point. Mid arm muscle circumference (MAMC), calculated from MAC and TSF, provides an index of muscle mass (somatic protein store).

MAMC (cm) = MAC (cm) – [3.14 × TSF (cm)].

## Mid Arm Muscle Circumference Standardization[5-8]

As there has been no standardization of MAMC measurements in Indian adults and the western reference values were higher, it was decided to assume the admission MAMC as standard. Weekly MAMC values were analyzed with respect to individual baseline MAMC and percent of gender-specific median MAMC at admission (≥ 90% normal, 80–90% mild, 60–80% moderate, and < 60% severe depletion).

## Outcome

The Glasgow Outcome Scale was used to assess outcome of patients at 3 months through telephonic interview. Good recovery or moderate disability was considered to be favorable and the rest unfavorable outcome.

## Statistics[9]

SPSS software (version 10; SPSS Inc.) was used for the statistical analyses. Normality of admission MAMC distribution was confirmed with indices of skewness and kurtosis. The changes in nutritional status over time were analyzed by using repeated measures analysis with post hoc Bonferroni multiple comparisons. Continuous variables were compared by using independent-samples *t*-test. Proportions were compared by using chi-square tests or Fisher's exact test whenever appropriate. Multivariate analysis was conducted with binary logistic regression model. Subgroup analysis was performed with Breslow–Day test for homogeneity of odds ratio (OR). Two-sided significance tests were used throughout, and the significance level was kept at $p = 0.05$.

## Results

A total of 114 adult patients that fulfilled the eligibility criteria were enrolled for the study. Eight were females. Out of these 114 patients, 67 were prospectively assessed weekly till 21 days for changes in anthropometric parameters during the hospital stay, the other 19 were discharged and 28 patients expired before 21 days. Among those who were enrolled (114), 73 patients had completed 3 months' follow-up and the others had follow-up ranging from 3 weeks up to 3 months.

The admission MAMC values in either sex are as shown in ►**Table 1**.

The anthropometric measurements showed significant fall at every week. The percentage fall at 3 weeks for MAC, MAMC, and TSF were 14, 10, and 37%, respectively (►**Figs. 1**–**3**).

**Table 1** Admission MAMC values (in cm)

| | Males | Females |
|---|---|---|
| Number | 106 | 8 |
| Range | 15.8–31.4 | 21.2–23.9 |
| Mean | 22.69 | 22.69 |
| Median | 22.4 | 22.5 |
| SD | 2.63 | 0.94 |

Abbreviations: MAMC, mid arm muscle circumference; SD, standard deviation.

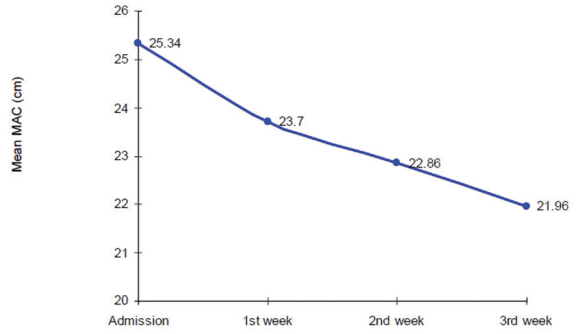


**Fig.1** Changes in mid arm circumference (MAC).

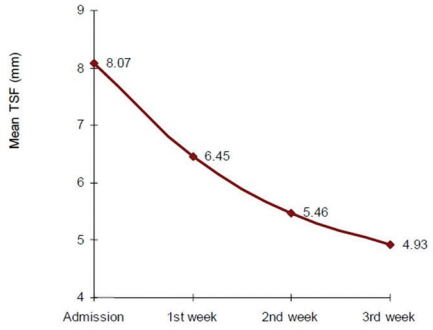


**Fig. 2** Changes in triceps skin fold thickness (TSF).

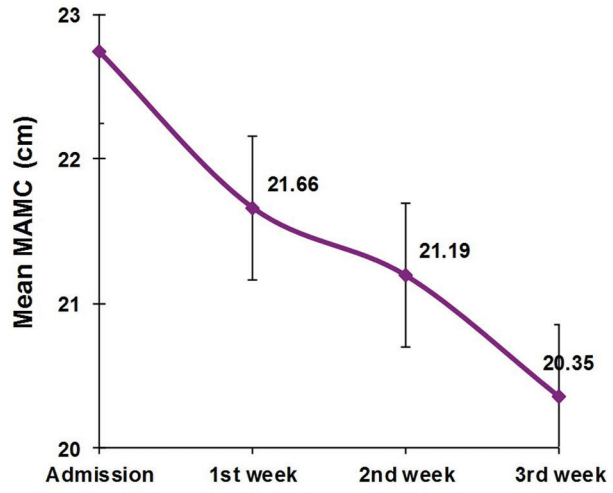


**Fig. 3** Changes in mid arm muscle circumference (MAMC).

The fall in MAMC was the earliest with mean MAMC value of patients at 3 weeks being 20.35 cm compared with 22.69 cm at admission ($p < 0.001$) (►**Fig. 3**). The weekly prevalence of different degrees of nutritional depletion was as shown in ►**Fig. 4**. There was a progressive worsening of nutritional status with almost 50% of patients malnourished at 3 weeks. No patient had MAMC < 60% of standard.

The 24-hour urinary creatinine excretion was tested at the end of the study period to confirm the validity of MAMC fall in detecting somatic protein depletion and found to be significant ($p$-value 0.04) (►**Fig. 5**).

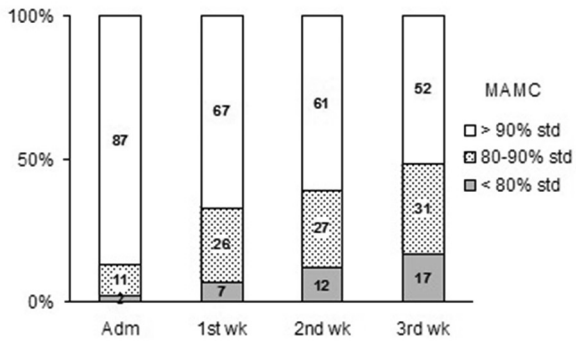


**Fig. 4** Prevalence of malnutrition. Adm, admission; std, standard.

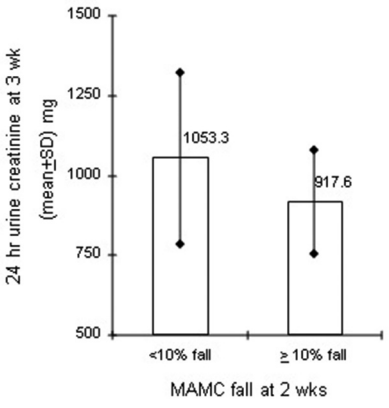


**Fig. 5** Mid arm muscle circumference (MAMC) fall versus urine creatinine.

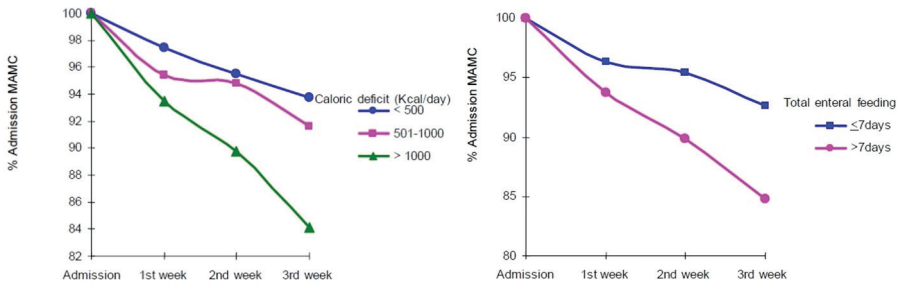


**Fig. 6** Fall in mid arm muscle circumference (MAMC) versus feeding.

Among the various factors studied for their influence on MAMC values, delayed attainment (> 7 days) of total enteral feeding, surgical intervention, and prolonged ventilation (> 7 days) were found to be significantly associated with greater degree of MAMC fall with *p*-values < 0.001, 0.03, and 0.03, respectively (►**Figs. 6**–**8**). Prolonged fever (> 7 days) was marginally associated with MAMC fall with *p*-value of 0.05. There was no significant association of age, GCS, and associated systemic injury with fall in MAMC.

## Outcome

As shown in ►**Fig. 9,** unfavorable outcome was noted in 52% of patients with normal admission MAMC compared with 85 and 100% of those with mild and moderate depletion, respectively (*p*-value 0.04). Admission MAMC < 90% of standard was significantly associated with unfavorable outcome with OR of 5.9 (95% confidence interval [CI] 1.3–27.8) and *p*-value of 0.01. Also, there was a significant association of MAMC at admission with the mortality (OR 3.8, *p*-value 0.03) (►**Fig. 10**).

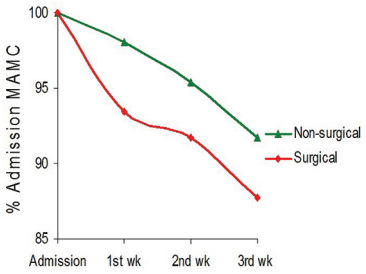


**Fig. 7** Fall in mid arm muscle circumference (MAMC) versus surgical intervention.

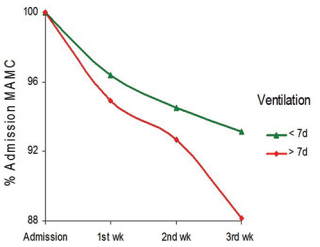


**Fig. 8** Fall in mid arm muscle circumference (MAMC) versus prolonged ventilation.

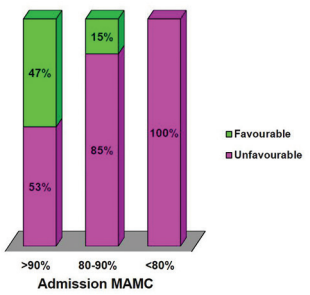


**Fig. 9** Admission mid arm muscle circumference (MAMC) versus outcome.

Unfavorable outcome at 3 months was observed in 71% of patients with 2-week MAMC fall ≥ 10% baseline value compared with 38% of those with < 10% fall. The OR was 3.9 (95% CI 1.1–13.5) and *p*-value of 0.03 (►**Fig. 11**). Its association with mortality was not significant. Subgroup analysis did not reveal any significant difference across GCS. Unfavorable outcome was also significantly more frequent in patients who had at least 15% fall in MAC (85.7 vs. 41.9%, $p = 0.03$). Fall in TSF had no significant association with outcome at 3 months. Other factors with significant impact on outcome were age and GCS.

## Multivariate Analysis

Logistic regression analysis was performed adjusting for age, GCS, admission anthropometric values, associated systemic injury, surgical intervention, and percent fall in anthropometry. It was noted that only GCS and MAMC fall were significantly associated with unfavorable outcome at 3 months (►**Table 2**).

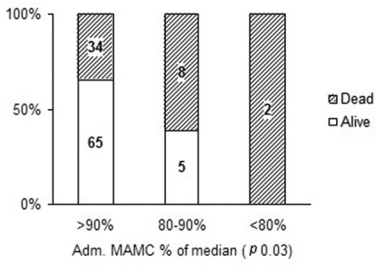


**Fig. 10** Admission mid arm muscle circumference (MAMC) versus mortality.

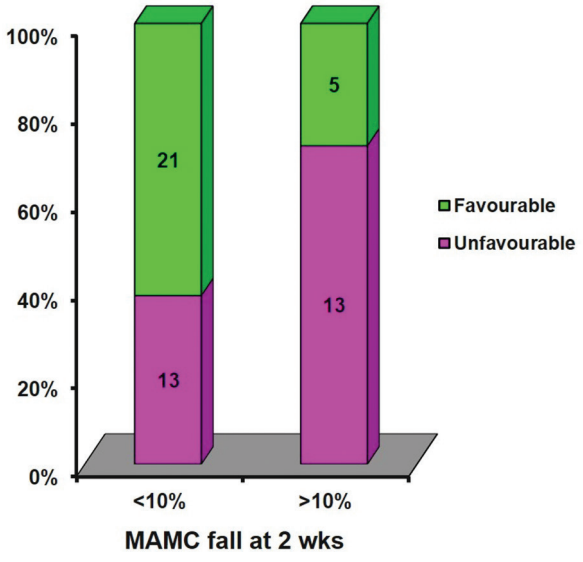


**Fig. 11** Mid arm muscle circumference (MAMC) fall versus outcome at 3 months.

**Table 2** Logistic regression

| Factor | Adjusted OR for unfavorable outcome (95% CI) | *p*-Value |
|---|---|---|
| GCS 4, 5 | 9.1 (2–41.7) | 0.004 |
| MAMC fall ≥ 10% | 9.3 (1.5–57) | 0.02 |

Abbreviations: CI, confidence interval; GCS, Glasgow Coma Scale; MAMC, mid arm muscle circumference; OR, odds ratio.

## Discussion

Severe head injury continues to be a nightmare due to the associated high mortality and morbidity, and contributes immensely to socioeconomic losses in India and other developing countries.[10-12] SHI increases the body's metabolic responses, and therefore nutritional demands, similar to subarachnoid hemorrhage.[13-15] Fasting along with hypermetabolism increases the rate of gluconeogenesis resulting in mobilization of amino acids initially from skeletal muscles and later from other visceral organs, which in turn leads to severe wasting of the lean body mass, impairment of vital organ function, and diminution in reparative and immune process.[16,17] Monitoring of nutritional status in patients of traumatic brain injury is vital, as it can guide us toward better nutritional management. Numerous studies have reported the changes in biochemical measures like resting metabolic expenditure, nitrogen excretion, blood glucose, homocysteine, magnesium, and serum albumin in patients of SHI.[13,15,18–23] But no study has been done so far on anthropometric assessment in patients of SHI.

As the routine measurements of weight and height are difficult to be used in patients of SHI, we had selected MAMC assessment. It is an indicator of somatic protein reserve which is the first to show depletion in inadequate nutritional supplementation. Based on 24-hour urinary creatinine, we have noted in our study that MAMC fall at 2 weeks effectively estimates muscle mass at 3 weeks. Moreover, this study clearly shows that nutritional assessment on the basis of MAMC can be used to identify patients at increased risk for poor outcome, so that aggressive nutritional support can be provided to them. Though both admission MAMC levels and percent fall in MAMC at 2 weeks were associated with unfavorable outcome on univariate analysis, only the latter was found to be significant in multivariate analysis. This may possibly indicate that even those who had mild depletion at admission, if prevented from falling further can have improved outcome. Due to the significant impact of more than 10% fall in MAMC at 2 weeks, it can be used as an outcome measure in future studies comparing different methods of nutritional supplementation. It can also be used in auditing the efficiency of the nutritional management in hospitals. Though the standards of anthropometric measurements may vary in different places, the percent fall in MAMC with respect to baseline is a potential marker of nutritional depletion across boundaries.

## Conclusion

Mid arm muscle circumference monitoring is efficient in identifying patients with nutrition depletion with significant influence on outcome at 3 months.

**Conflict of Interest**

None.

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