The prediction of in-hospital mortality by mid-upper arm circumference
a prospective observational study of the association between mid-upper arm circumference and the outcome of acutely ill medical patients admitted to a resource-poor hospital in sub-Saharan Africa
Kitovu Hospital Study Group

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Measurements have been used to assess nutrition including: height, weight, body mass index (BMI), skin fold thickness etc. Mid-upper arm circumference (MUAC) is a simple, cheap and practical measure of nutrition that is recommended by the World Health Organization. It is in widespread use, particularly in children in the developing world.  Although children and adults with a low MUAC are at an increased risk of dying, there are only a few reports of the association of MUAC with the in-hospital mortality of acutely ill patients. This study reports the association between MUAC and the in-hospital mortality of 899 acutely ill medical patients treated in a resource-poor hospital in sub-Saharan Africa. It also compares MUAC with other predictors of in-hospital mortality such as age, mental alertness, functional capacity and vital signs.

Methods
This prospective observational study was performed on a 46-bed medical ward at St Joseph’s Kitovu Health Care Complex, which has 220 beds and is located near Masaka, Uganda, 140 km from the capital city of Kampala. Together with the 330-bed Masaka Regional Referral Government Hospital, it serves Masaka Municipality (population of 79,200) and Masaka District, with a rural population of 804,300. From 9 August 2016 to 16 May 2017 the clinical status and vital signs of every patient admitted to the hospital’s medical unit were entered on admission and at least daily at the bedside using tablet computers into a clinical data management and decision support system (rapid electronic assessment data system [READS], Tapa Healthcare DAC) by two dedicated nurse researchers, who worked between them from 9am to 5pm 7-days-a-week. All the patients admitted were acutely ill, and no patients were excluded from the study. The READS bedside assessment requires that the patient’s contemporaneous mental alertness, mobility and complaints are entered each time the vital signs are measured. Any patient who was not alert and calm was deemed to have altered alertness, and to have impaired mobility if they did not have a stable independent gait. The final disposition of patients was also recorded in the system. All data entries were automatically time and date stamped. In addition to the electronic READS...
assessment, the research nurses were also asked to record on paper each patient’s MUAC. The National Early Warning Score (NEWS), a well-validated predictor of imminent mortality, was calculated from the respiratory rate, systolic blood pressure, level of consciousness, temperature, oxygen saturations, and inspired oxygen concentration. Calculations were performed using Epi-Info version 6.0 (Centers for Disease Control and Prevention, USA), logistic regression analysis using logistic software. The p-value for statistical significance was 0.05 and was tested using Student’s t-test. Ethical approval of the study was obtained from the Ethics Committee Kitovu Hospital, which waived the need for written consent. The study is reported in accordance with the STROBE statement.

Results
Of the 1069 patients 16 years or older admitted during the study period only 170 (15.9%) did not have their MUAC measured. Apart from a shorter length of hospital stay (71.4 days [SD 61.1 hours] vs 84.5 days [SD 63.0 hours], p=0.01) there were no significant differences between these patients and the final study population of 899 patients, who had a mean age of 50.3 years (SD 21.7 years) and 366 (58.9%) of whom were male. On admission, 62 patients (6.9%) had altered alertness and 384 (42.7%) had impaired mobility. The HIV status was only known in 85 patients; 49 were positive and 36 negative. Within a mean length of stay of 84.5 days (SD 63.0 hours), 682 (75.9%) patients were discharged independent of the care of others, 115 (12.8%) were discharged dependent on others, 38 (4.2%) had been transferred to another hospital, and 64 (7.1%) had died. There was no significant difference in the age, length of hospital stay or the temperature on admission of patients who died compared with those who survived until discharge. However, compared to survivors, patients who died had higher heart and respiratory rates and NEWS, and lower systolic blood pressures, oxygen saturation levels and MUAC (Table 1).

Table 1. Values of continuous variables of all patients and those who died in hospital compared with those who survived

| Variable                  | Total         | Alive      | Dead        | p-value |
|---------------------------|---------------|------------|-------------|---------|
| **Age (years)**           |               |            |             |         |
| Mean (SD)                 | 50.3 (21.7)   | 49.9 (21.5) | 55.2 (24.1) | 0.06    |
| Median (Range)            | 50 (16–105)   | 50.0 (16–105) | 57.5 (19–105) |         |
| **Length of stay (hours)**|               |            |             |         |
| Mean (SD)                 | 84.5 (63.0)   | 84.3 (61.6) | 87.0 (79.3) | 0.74    |
| Median (Range)            | 73 (1–551)    | 73 (1–551) | 70 (3–356)  |         |
| **Heart rate (bpm)**      |               |            |             |         |
| Mean (SD)                 | 86.5 (18.9)   | 85.6 (17.8) | 97.8 (27.4) | <0.00001 |
| Median (Range)            | 84 (38–190)   | 84 (38–190) | 98 (48–158) |         |
| **Respiratory rate (bpm)**|               |            |             |         |
| Mean (SD)                 | 23.1 (6.8)    | 22.5 (6.1)  | 30.6 (10.1) | <0.00001 |
| Median (Range)            | 22 (12.0–50.0)| 21.0 (12.0–50.0) | 27.0 (15.0–50.0) |         |
| **SBP (mmHg)**            |               |            |             |         |
| Mean (SD)                 | 112.7 (0.9)   | 113.3 (24.9) | 105.3 (31.6) | 0.02    |
| Median (Range)            | 110.0 (50.0–214.0) | 111.0 (50.0–214.0) | 100.0 (50.0–190.0) |         |
| **Temperature (°C)**      |               |            |             |         |
| Mean (SD)                 | 36.8 (1.0)    | 36.8 (0.9) | 36.9 (2.2)  | 0.20    |
| Median (Range)            | 36.7 (24.0–50.0) | 36.7 (24.0–41.1) | 36.5 (29.0–50.0) |         |
| **Oxygen saturation (%)** |               |            |             |         |
| Mean (SD)                 | 94.5 (7.3)    | 95.0 (6.4) | 88.3 (13.6) | <0.00001 |
| Median (Range)            | 97 (36–99)    | 97 (38–99) | 92 (36–99)  |         |
| **NEWS**                  |               |            |             |         |
| Mean (SD)                 | 4.1 (3.1)     | 3.8 (2.8)  | 8.4 (3.2)   | <0.00001 |
| Median (Range)            | 4.0 (0–17)    | 3.0 (0–14) | 8.0 (0–17)  |         |
| **MUAC (cm)**             |               |            |             |         |
| Mean (SD)                 | 26.1 (4.3)    | 26.3 (4.3) | 23.9 (3.6)  | 0.00002  |
| Median (Range)            | 26.0 (15.0–43.0) | 26.0 (15.0–43.0) | 23.5 (16.0–31.5) |         |

bpm = beats or breaths per minute; MUAC = mid-upper arm circumference; NEWS = National Early Warning Score; SBP = systolic blood pressure; SD = standard deviation
Mid-upper arm circumference ranged from 15 cm to 42 cm. Twelve (24%) of the 50 patients with a MUAC less than 20 cm died; however, none of the 78 patients with a MUAC ≥20 cm died (Fig 1). A MUAC below 20 cm and a NEWS ≥7 had the highest chi-square value for in-hospital mortality (OR 4.8, 95% CI 2.23–10.37). In contrast, nearly a quarter of the patients with a MUAC ≥28 cm were almost four times more likely to survive. This is a small single-centre study, performed in a resource-poor hospital in sub-Saharan Africa that only reports in-hospital mortality; patient diagnoses and long term outcomes were not examined. Since diagnostic investigations were limited, and no autopsies were performed, any diagnoses made would have been based on local expert opinion. In contrast, the parameters examined in this study are all objective and require little skill to measure. HIV status was known in only a small number of patients. However, there was no difference in the MUAC or in-hospital mortality of those patients known to be HIV positive compared with those known to be HIV negative. As far as we know, there was no selection bias for the patients who did not have their MUAC measured. HIV status was known in only a small number of examined in this study are all objective and require little skill to measure. HIV status was known in only a small number of patients. However, there was no difference in the MUAC or in-hospital mortality of those patients known to be HIV positive compared with those known to be HIV negative. As far as we know, there was no selection bias for the patients who did not have their MUAC measured. HIV status was known in only a small number of patients. However, there was no difference in the MUAC or in-hospital mortality of those patients known to be HIV positive compared with those known to be HIV negative. As far as we know, there was no selection bias for the patients who did not have their MUAC recorded did have a shorter length of stay, so if the measurement was overlooked at the time of the first assessment, the patient diagnoses and long term outcomes were not examined. Since diagnostic investigations were limited, and no autopsies were performed, any diagnoses made would have been based on local expert opinion. In contrast, the parameters examined in this study are all objective and require little skill to measure. HIV status was known in only a small number of patients. However, there was no difference in the MUAC or in-hospital mortality of those patients known to be HIV positive compared with those known to be HIV negative. As far as we know, there was no selection bias for the patients who did not have their MUAC.

**Discussion**

This study shows that MUAC is a predictor of the in-hospital mortality of acutely ill medical patients in sub-Saharan Africa, which is independent of age, gender, mental alertness, impaired mobility and vital signs. Patients with a MUAC <20 cm were almost five times more likely to die in hospital, and those with a MUAC ≥28 cm were almost four times more likely to survive.

**Prediction of in-hospital mortality by MUAC**

![Graph](image)

**Table 1. In-hospital mortality associated with categorical variables**

| Parameter          | Odds ratio (95% CI) | Chi-square | p-value |
|--------------------|---------------------|------------|---------|
| NEWS ≥7            | 17.28 (8.93–33.95)  | 127.6      | <0.00001|
| Altered alertness  | 9.66 (4.89–18.24)   | 67.8       | <0.00001|
| Impaired mobility  | 8.26 (3.97–17.66)   | 47.1       | <0.00001|
| Supplemental oxygen| 5.20 (2.45–10.92)   | 23.9       | <0.00001|
| MUAC <20 cm        | 4.84 (2.23–10.37)   | 20.2       | <0.00001|
| MUAC ≥28 cm        | 0.27 (0.10–0.67)    | 9.3        | 0.002    |
| Male               | 1.31 (0.76–2.26)    | 0.8        | 0.36     |

See text for definitions of 'Altered alertness' and 'Impaired mobility'. CI = confidence interval; MUAC = mid-upper arm circumference; NEWS = National Early Warning Score.

**Table 3. Odds ratio for in-hospital mortality of the four parameters found by logistic regression to be independent predictors, calculated with NEWS and MUAC as either categorical or continuous variables**

| Parameter          | Odds ratio (95% CI) | p-value |
|--------------------|---------------------|---------|
| NEWS and MUAC as categorical parameters | | |
| NEWS ≥7            | 10.75 (5.63–20.56)  | <0.00001|
| MUAC <20 cm        | 3.45 (1.46–8.16)    | 0.0049  |
| Altered alertness  | 3.70 (1.79–7.64)    | 0.0004  |
| Impaired mobility  | 3.72 (1.76–7.89)    | 0.0006  |

Hosmer-Lemeshow goodness-of-fit p-value of 0.19

**NEWS and MUAC as continuous parameters**

| NEWS  | 1.44 (1.30–1.60) | <0.00001 |
| MUAC (cm) | 0.92 (0.85–0.99) | 0.03    |
| Altered alertness | 2.75 (1.33–5.71) | 0.007   |
| Impaired mobility  | 3.32 (1.56–7.05) | 0.002   |

Hosmer-Lemeshow goodness-of-fit p-value of 0.20

See text for definitions of ‘Altered alertness’ and ‘Impaired mobility’. MUAC = mid-upper arm circumference; NEWS = National Early Warning Score.
may have been discharged before there was time to correct the oversight. This study examined the association between in-hospital mortality and MUAC in our patient population. There are, of course, many factors that influence MUAC, including malnutrition and poverty; all of our patients were poor. Diagnoses are also major confounding factors. Although patient diagnoses were not studied, common conditions and causes of mortality in our patient population are HIV-related illness, diabetes and tuberculosis. All these conditions are associated with weight loss. Therefore, it is possible that the relationship between low MUAC and mortality may be explained by reverse causation (ie mortality was not caused by the low MUAC, but by the underlying illnesses that caused both weight loss and the patient to die). Similarly, patients with a high MUAC would have less chance of suffering from fatal diseases that cause weight loss. It might be assumed that MUAC measurement in acutely ill patients will be of less value in the developed world, where tuberculosis and HIV are relatively uncommon. However, Powell-Tuck and Hennessy reported that a low MUAC predicted mortality in acutely ill patients attending the Royal London Hospital better than their body mass index. They did not find, however, that an increased MUAC was associated with a reduced mortality. Indeed, a long term follow-up study has reported that both a high and low MUAC are associated with an increased mortality. Nevertheless, there is increasing evidence that moderate obesity improves the survival of sick patients. This reverse epidemiology was first reported in renal dialysis patients, but has since been observed in heart failure, the elderly, chronic obstructive pulmonary disease (COPD) and intensive care patients with sepsis, pneumonia and acute lung injury. It is possible, therefore, that what might be considered as excessive nutrition provides a survival benefit to patients with infection and other acute illness.

Regardless of whether or not a high MUAC is protective and a low MUAC causes mortality, the measurement is easy to perform and a powerful independent predictor of in-hospital outcome. It is a quick, simple and cheap observation that can be carried out anywhere by a single operator, and requires only a tape measure and little training or expertise to perform. The measurement of MUAC is widespread in African paediatric wards, and both of our nurses were familiar with the technique. Moreno et al have studied its interobserver and intraobserver error in adolescents and found an interobserver technical error of measurement of 0.47 cm and an intraobserver coefficient of reliability of 97%. In contrast, accurately measuring height and body weight to calculate body mass index can be extremely difficult in bedridden, severely ill patients. Moreover, there is some evidence that since MUAC measures both fat and muscle, it may be a better indicator of nutritional status.

Conclusion

Mid-upper arm circumference is confirmed as a powerful independent predictor of the in-hospital mortality of acutely ill medical patients in a resource-poor hospital in sub-Saharan Africa. It can be measured quickly and easily at no cost. A review of the available literature suggests that it should be valuable in the risk assessment of acute illness in other patient populations.

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Funding and conflicts of interest

All other costs were borne by the authors. John Kellett is a major shareholder, director and chief medical officer of Tapa Healthcare DAC.

Consent

This was an observational study that is part of an ongoing quality improvement project. This study conformed to the principles outlined in the Declaration of Helsinki and was approved by the hospital’s ethics committee; assessment of nutritional status on all patients is strongly encouraged by the Ugandan Ministry of Health and no patients refused measurement of their mid-upper arm circumference which is part of routine practice.

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