Estimating Weight of Patients With Acute Stroke When Dosing for Thrombolysis

Tom Barrow, BSc; Muhammad S. Khan, MSc; Omid Halse, MRCP; Paul Bentley, PhD; Pankaj Sharma, MD, PhD, FRCP

Background and Purpose—Estimating patient weight forms an important part of emergency ischemic stroke management guiding the dose of alteplase (tissue-type plasminogen activator). Weighing patients with stroke can be logistically challenging and time consuming, potentially delaying treatment times. We aimed to assess the reliability of approximating weight to determine recombinant tissue-type plasminogen activator dose and whether potential inaccurate dosing affected patient outcomes.

Methods—Two hundred forty-two consecutive patients were studied at a large tertiary stroke center. Estimated and actual measured weight, alteplase dose, and pre-and post-modified Rankin Scale/National Institute of Health Stroke Scale outcome were recorded for each patient.

Results—Clinicians significantly underestimated weights by 1.13 kg (range, −43 to +18 kg; SD, 7.14; \( P < 0.05 \)). The difference between estimated and actual weight proved to be greatest in the heaviest third of patients (−4.51 kg; SD, 8.35; \( P < 0.001 \)), resulting in 19.7% of patients receiving a deviation of at least 10% from the recommended recombinant tissue-type plasminogen activator dose. On average, the heaviest third of patients received an underdose of 0.04 mg/kg and were found to have a greater baseline National Institute of Health Stroke Scale on admission (\( P < 0.001 \)). National Institute of Health Stroke Scale improvement by day 7 or on discharge was significantly reduced in patients weighing >78 kg (National Institute of Health Stroke Scale score difference of 4.0 points, \( P < 0.05 \)) than in lighter individuals.

Conclusions—Clinicians are poor at approximating the weights of patients with stroke in the acute setting, especially when patients lie at the extremes of weight. Beds capable of weighing patients should be mandated in emergency rooms for patients with acute stroke. (Stroke. 2016;47:228-231. DOI: 10.1161/STROKEAHA.115.011436.)

Key Words: cerebral hemorrhage □ comorbidity □ regression analysis □ stroke □ tissue plasminogen activator and National Institute of Health Stroke Scale (NIHSS) outcome measures.

Methods

Data Extraction

Data from 242 patients with stroke from a tertiary London stroke center (Imperial College London, Hammersmith Hospitals, Charing Cross Hospital and St Mary’s Hospital) were analyzed. Stroke specialist nurses and attending physicians estimated weight on acute presentation, which determined r-tPA dose. The following day, the weight of patients was formally measured using clinical ward scales and a weight estimation error calculated. Difference in alteplase dose (mg) between estimated weight and actual weight was calculated using the accepted dose of 0.9 mg/kg. Outcome measures recorded were NIHSS (recorded pre–r-tPA administration, after 2, 24, and 72 hours, and at 7 days or on discharge) and mRS score (recorded premorbidly and at 7 days/on discharge). Improvement was calculated by subtracting scores at 7 days/on discharge from admission scores.
Statistical Analyses
Data were analyzed using SPSS v21 (IBM, New York, NY). A paired t test between estimated weight and measured weight determined difference between these variables. Thereafter, univariate analysis to identify variables associated with the weight estimation error variable was undertaken. Variables found to be significant were included in a multivariable regression analysis alongside variables determined to be biologically significant (age, sex, pre–r-tPA NIHSS, and comorbidities). The population was divided into tertiles based on measured weight and compared with one another for the weight estimation error using analysis of variance.

A deviation of ±10% dose from 0.9 mg/kg was used as a range for acceptable dosing of r-tPA. Frequencies were then obtained for patients receiving an acceptable dose of 0.81 to 0.99 mg/kg, overdose >0.99 mg or underdose <0.81 mg/kg. To investigate whether misdosing had an effect on functional outcome, we categorized the mRS at 7 days/on discharge into 2 separate dichotomous variables. mRS was divided into favorable outcome (0–1) and unfavorable outcome (2–6), as well as independent outcome (0–2) and dependent outcome (3–6). A binary logistic regression was then performed to ascertain any significant relationship between dosing and outcome.

Dose of alteplase (mg) was calculated for both estimated weight and measured weight for each tertile group and compared with a paired t test. Tertiles of measured weight were compared against one another for NIHSS improvement to determine any change in the magnitude of recovery between groups. Dose deviation from the optimum dose was calculated.

Results
Demographic details of the study population are presented in Table 1.

Clinicians underestimated mean difference weight by 1.13 kg (P<0.05) between estimated (71.41; SD, 14.20) and actual measured weight (72.54; SD, 16.17). Results were not altered after adjustment for covariables of age, sex, pre–r-tPA NIHSS, oral anticoagulants, and comorbidities using univariate and multivariate analysis.

To determine whether extremes of weight affected weight estimation, measured weight was divided into tertiles. Tertile 1 represents the lightest 81 patients weighing between 37 and 64.5 kg; tertile 2, 80 patients weighing 64.6 to 77.8 kg; and tertile 3, 81 patients weighing from 77.9 to 120 kg. Table 2 illustrates that the estimated weight error for individuals in the third (heaviest) tertile was significantly different from the lower tertiles (P<0.001). This association remained significant after removing patients with estimated weights >100 kg and after adjustment for covariables. The difference in mean weight estimation error between tertile 1 and 2 was 2.4 kg (P=0.026). Similarly, the difference in mean weight estimation error between tertile 1 and 3 was 7.3 kg (P<0.001). To show that the margin of weight estimation error was greater at the extremes of weight, percentage error was calculated for each tertile and plotted (Figure I in the online-only Data Supplement).

Effect of Estimation Error on Dose
Using the range 0.81 to 0.99 mg/kg as an acceptable dose, patients were divided into 3 groups: underdose, acceptable dose, and overdose. The majority of patients (80.3%) received a dose within the acceptable range. Consistent with underestimation of weight, more patients were in the underdosed category than the overdosed category, 11.5% and 8.1%, respectively.
A paired t test was performed for each tertile of measured weight, comparing the estimated weight-based dose and the measured weight-based dose (Table 3). In the lowest and highest tertiles, this difference proved to be significant ($P<0.05$). Patients in tertile 3 received an average dose of 77.6 mg where they should have received 80.0 mg, a deficit of 3.0%. By contrast, tertile 1 received 51.54 mg where they should have received 50.33 mg, resulting in an overdose of 2.42%. Using a dose error margin of ±10%, 7.1% of patients received an inaccurate dose ($P=0.01$).

**Effect of Estimation Error on Clinical Outcome**

We divided mRS at 7 days/on discharge into favorable/unfavorable outcome and independent/dependent outcome; 58.1% of patients achieved a favorable outcome defined as mRS between 0 and 1. With an independent outcome, mRS between 0 and 2, this value increases to 70.0%.

Dosing groups defined as underdosed, acceptable dose, and overdosed were then analyzed to determine their effect on the mRS outcomes: favorable/unfavorable and independent/dependent. Dosing errors proved to have no effect on mRS measured outcome. Dosing groups were also compared with intracerebral hemorrhage rates but also had no effect ($P>0.05$).

The NIHSS score improved from 9.9 to 4.4 between admission and 7 days/discharge on average (Table 1). Improvement in NIHSS was calculated to analyze the magnitude of recovery seen in different patient groups. Dose deviation from the optimum dose of 0.9 mg/kg was also calculated. A correlation was observed between measured weight and pre-tPA–adjusted NIHSS score, implying that heavier patients have more severe strokes ($P<0.001$). Tertile 3 (heaviest) group had the largest mean deviation in dose of −0.04 mg/kg and the smallest improvement in NIHSS of 4.00. Patients in tertile 2 (average) were accurately dosed with a mean deviation of −0.02 mg/kg. This group saw the greatest improvement in NIHSS score for tertile 3, which represents one third of our population.

The NIHSS score improved by day 7/discharge on average (Table 1). Improvement in NIHSS was calculated to analyze the magnitude of recovery seen in different patient groups. Dose deviation from the optimum dose of 0.9 mg/kg was also calculated. A correlation was observed between measured weight and pre-tPA–adjusted NIHSS score, implying that heavier patients have more severe strokes ($P<0.001$). Tertile 3 (heaviest) group had the largest mean deviation in dose of −0.04 mg/kg and the smallest improvement in NIHSS of 4.00. Patients in tertile 2 (average) were accurately dosed with a mean deviation of −0.02 mg/kg. This group saw the greatest improvement in NIHSS score for tertile 3, which represents one third of our population.

As a consequence of estimation errors, incorrect dosing could negatively impact on patient outcome (increased intracerebral hemorrhage or ineffective thrombolysis). The majority of those in our study receiving an inaccurate dose were underdosed.

Those in tertile 2 were most appropriately dosed and saw the greatest improvement in NIHSS score. Conversely, those receiving the largest deviation in dose had a comparatively reduced improvement in NIHSS score by day 7/discharge. Heavier patients were also noted to have more severe baseline NIHSS scores and therefore have a greater potential benefit from appropriate thrombolysis, although may derive less benefit from r-tPA, but this does not explain the reduced improvement in NIHSS score for tertile 3, which represents one third of our population.

Other investigators have also demonstrated a large variation in the accuracy of weight estimations with clinicians possibly better at estimating weights closer to their own. The error rate for our study population was 19.7%, which falls between 2 previous studies of 38.2% and 14.9%. Estimating weight to determine r-tPA dose is certainly more widely practiced compared with anthropometric measurements, which can take as long as formally weighing patients.

Although our study is one of the largest conducted on weight estimation in the acute stroke setting to date and the
only study to include NIHSS outcomes in addition to mRS.\textsuperscript{1–3} many limitations need to be considered. This was a retrospective study and subject to that bias. However, the data analyzed were from an extensive database of all consecutive patients with acute stroke admitted no matter what time of day. We, therefore, think that all patients have been captured. Although weight was measured within 24 hours, it may differ slightly from admission weight because of the effects of dehydration. Although weight estimation is necessary to determine tPA dose for the majority of patients, individuals weighing >100 kg receive the maximum dose, and therefore, weight estimation has no bearing on these individuals (and our results were preserved when these 17 patients were excluded). The study was conducted in a single city, London, United Kingdom. However, this capital city houses some of the largest acute stroke units in the country admitting nearly 2000 patients with stroke per year. Thus, we think that our data and results are likely to be representative of most stroke units. Finally, we would argue that those with the heaviest weight have the worst outcomes because of dosing errors, but it is possible that their outcomes were worse because of associated comorbidity although this was not the case in another large study addressing this issue.\textsuperscript{5} Notwithstanding this evidence, being overweight could be associated with bad outcome and underdosing may be a contributing factor to that outcome.

We conclude clinicians are poor at approximating the weights of patients with stroke in the acute setting, especially at the extremes of weight. These heaviest patients, approximately 1 in 3 of all thrombolysed patients, tend to be underdosed, which may lead to poorer outcomes. Our results argue in favor of beds capable of weighing patients in emergency rooms for patients with acute stroke who are unable to report their own weight.

**Acknowledgments**

P. Sharma is a former UK Department of Health Senior Fellow. He devised the idea and supervised the project. T. Barrow undertook the data collection, initial analysis, and wrote the first draft. M.S. Khan undertook the analysis. P. Bentley and O. Halse advised and supervised on the clinical aspects. All authors contributed to the final version of the article.

**Disclosures**

None

**References**

Estimating Weight of Patients With Acute Stroke When Dosing for Thrombolysis
Tom Barrow, Muhammad S. Khan, Omid Halse, Paul Bentley and Pankaj Sharma

*Stroke*. 2016;47:228-231; originally published online November 10, 2015;
doi: 10.1161/STROKEAHA.115.011436

*Stroke* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2015 American Heart Association, Inc. All rights reserved.
Print ISSN: 0039-2499. Online ISSN: 1524-4628

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://stroke.ahajournals.org/content/47/1/228

Data Supplement (unedited) at:
http://stroke.ahajournals.org/content/suppl/2015/11/10/STROKEAHA.115.011436.DC1

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in *Stroke* can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to *Stroke* is online at:
http://stroke.ahajournals.org//subscriptions/
Supplemental Figure I:

Percentage estimation error of weight by tertiles of weight. Weight estimation error was greater at the extremes of weight (Tertile 1 & 3)