Dehydration in Hospital-Admitted Stroke Patients
Detection, Frequency, and Association
Anne Rowat, PhD; Catriona Graham, MSc; Martin Dennis, MD

Background and Purpose—We aimed to determine the frequency of dehydration, risk factors, and associations with outcomes at hospital discharge after stroke.

Methods—We linked clinical data from stroke patients in 2 prospective hospital registers with routine blood urea and creatinine results. Dehydration was defined by a blood urea-to-creatinine ratio >80.

Results—Of 2591 patients registered, 1606 (62%) were dehydrated at some point during their admission. Independent risk factors for dehydration included older age, female gender, total anterior circulation syndrome, and prescribed diuretics (all \( P < 0.001 \)). Patients with dehydration were significantly more likely to be dead or dependent at hospital discharge than those without (\( \chi^2 = 170.5 \); degrees of freedom=2; \( P < 0.0001 \)).

Conclusions—Dehydration is common and associated with poor outcomes. Further work is required to establish if these associations are causal and if preventing or treating dehydration improves outcomes. (Stroke. 2012;43:857-859.)

Key Words: acute stroke ■ blood urea ■ creatinine ■ dehydration

Clinical guidelines emphasize the importance of adequate hydration after stroke. Dehydration after stroke increases the risk of venous thromboembolism and is associated with poor outcomes.1,2 Dehydration can be detected with biomarkers of reduced blood water, most commonly using the urea:creatinine (U:C) ratio and plasma osmolality. We aimed to measure the frequency, risk factors, and associations of dehydration based on U:C ratio (as the best indicator of hydration routinely available) in a large in-hospital stroke population.

Materials and Methods
The blood test results of 2778 stroke patients in 2 hospitals were measured as part of routine care between January 1, 2005 and December 31, 2008. These were linked with data from the Scottish Stroke Care Audit.1 We excluded patients who had an in-hospital stroke (n=16), were admitted >14 days after stroke onset (n=35), or had no identifiable blood tests (n=136). We used only the first recorded admission for the 2591 patients included in the analyses. This study was approved by the local Caldicott Guardian because it did not require researchers to access patient-identifiable data.

Dehydration was defined as U:C ratio of >80.3 Univariate associations between dehydration, stroke severity (based on a validated prognostic model),4 and factors (including prescription of diuretics, angiotensin-converting enzyme inhibitors, dysphagia, and parenteral/enteral feeding) were investigated with \( \chi^2 \) tests. We used a multivariate logistic regression model to identify independent associations between dehydration and explanatory factors that were significant (\( P < 0.05 \)) in the univariate analysis.

Results
A total of 19,503 U:C ratio blood tests were measured on 18,812 days in the 2591 patients. A median of 4 (interquartile range, 2–9) tests per patient were performed during a median length of admission of 17 (interquartile range, 5–54) days. Predictably, there was a strong positive correlation between the total number of blood tests per patient and the length of admission (correlation coefficient, 0.78; \( P < 0.001 \)).

Of the 2591 patients, 927 (36%) were dehydrated during their first blood test performed on the day of admission or the day after, another 679 (26%) were not dehydrated on admission but had at least 1 blood test indicating dehydration at some point during their admission, and 985 (38%) had normal hydration during their whole admission. Of the 1606 of 2591 (62%) patients with dehydration at some point during their admission, 998 of 1606 (62%) had >1 test showing dehydration on at least 2 days.

The Figure shows the number of patients in hospital and the number of patients with blood tests performed on each of the first 30 days, split by whether the test showed dehydration. The proportion of patients who had their blood tested compared to the total number of patients still in hospital on each day reduced over time from 2392 of 2591 (92%) on day 0 to 178 of 976 (18%) by day 30. Although fewer patients were tested between days 11 and 30, there were proportionally more tests showing dehydration (2936/4865; 60%) than tests taken between days 1 and 10 (2939/6038; 49%; Table 1).

Patients with dehydration within 1 day of admission (n=927) and those with dehydration at any stage of their admission (n=1606; Table 2) were both significantly more likely to be older, to be female, to have a total anterior circulation syndrome, to be prescribed diuretics, to require...
parenteral fluids and/or enteral tube feeding, and were predicted to be less likely to be alive/independent in daily activities at 6 months (based on their baseline features) than those who were not dehydrated (all $P<0.001$, Mann-Whitney $U$ tests). Dysphagia, parenteral fluids, and enteral tube feeding could not be included in a multivariable analysis because of the number of missing observations. On multivariable analysis (n=2591), dehydration at any time during admission was significantly less likely in men (OR, 0.55; 95% CI, 0.47–0.66) and in those with a predicted good outcome (OR, 0.17; 95% CI, 0.13, 0.23), but more likely in total anterior circulation syndrome (OR, 2.61; 95% CI, 1.92–3.56) and in those prescribed diuretics (OR, 1.98; 95% CI, 1.50–2.59).

Discharge destination was known for 2549 patients (n=42 missing). Of the 2549 stroke patients, 687 of 1580 (43%) with dehydration at some point during their admission died in hospital or were discharged to institutional care compared with 177 of 969 of patients without dehydration ($\chi^2 = 170.5$; degrees of freedom=2; $P<0.0001$).

Discussion

In this study, 36% of patients were dehydrated on the day of admission and 62% were dehydrated at some point during the first 30 days of hospital admission.

Table 1. Total Blood Urea-to-Creatine Ratio Tests (n=13 295), Not Patients, Indicating Dehydration or Not During the First 30 Days of Hospital Admissions

<table>
<thead>
<tr>
<th>Days</th>
<th>Hydrated Urea:Creatinine Ratio $\leq$80 mmol:mmol</th>
<th>N</th>
<th>%</th>
<th>Dehydrated Urea:Creatinine Ratio $&gt;80$ mmol:mmol</th>
<th>N</th>
<th>%</th>
<th>Total N Tests during Each Time Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1531</td>
<td>64</td>
<td>46</td>
<td>861</td>
<td>36</td>
<td>46</td>
<td>2392</td>
</tr>
<tr>
<td>1–10</td>
<td>3099</td>
<td>51</td>
<td>47</td>
<td>2939</td>
<td>49</td>
<td>53</td>
<td>6038</td>
</tr>
<tr>
<td>11–20</td>
<td>1180</td>
<td>40</td>
<td>44</td>
<td>1807</td>
<td>60</td>
<td>56</td>
<td>2987</td>
</tr>
<tr>
<td>21–30</td>
<td>749</td>
<td>40</td>
<td>44</td>
<td>1129</td>
<td>60</td>
<td>56</td>
<td>1878</td>
</tr>
<tr>
<td>Total 0–30</td>
<td>6559</td>
<td>49</td>
<td>46</td>
<td>6736</td>
<td>51</td>
<td>46</td>
<td>13 295</td>
</tr>
</tbody>
</table>

Percentages shown are out of the total number of tests during each time period.

Table 2. Comparison of Clinical Characteristics in Patients Classified as Hydrated (n=985) and Dehydrated (n=1606) During Their Entire Hospital Admission

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Hydrated Urea:Creatinine Ratio $\leq$80 mmol:mmol</th>
<th>N</th>
<th>%</th>
<th>Dehydrated Urea:Creatinine Ratio $&gt;80$ mmol:mmol</th>
<th>N</th>
<th>%</th>
<th>Total N Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>73 (61–80)</td>
<td>80</td>
<td>76</td>
<td>80 (72–86)</td>
<td>1606</td>
<td>76</td>
<td>13 295</td>
</tr>
<tr>
<td>Men (n)</td>
<td>569 (58%)</td>
<td>631</td>
<td>39</td>
<td>631 (39%)</td>
<td>1606</td>
<td>39</td>
<td>13 295</td>
</tr>
<tr>
<td>Acute Stroke Unit admission (n)</td>
<td>692 (70%)</td>
<td>1344</td>
<td>84</td>
<td>1344 (84%)</td>
<td>1606</td>
<td>84</td>
<td>13 295</td>
</tr>
</tbody>
</table>
| Length of admission (d)                     | 7 (3–19)                                        | 32 (10–74) | 1606 | 73 (5%)

Data are median (interquartile range) or N (%).

* $P<0.001$, Mann-Whitney $U$/$\chi^2$ tests.

†Factors included in a model to predict probability of stroke severity.4

Figure. The total number of patients in hospital on days 0 to 30 split by whether they had a urea-to-creatine (U:C) ratio measured, and whether that U:C ratio indicated dehydration.
their admission. As anticipated, greater age and indicators of severe stroke (total anterior circulation syndrome and a predicted outcome of dependency) were independent risk factors for dehydration. Diuretic use was strongly associated with dehydration. Stroke patients who use diuretics have been found to have higher plasma osmolality levels and peak blood urea nitrogen and creatinine levels compared to healthy control group patients using diuretics or not. The observation that women were more likely than men to have increased U:C ratios might, in part, be explained by their lower muscle mass and thus lower creatinine, but not urea levels. Our data confirm that dehydration is associated with poor outcome on hospital discharge.

The strength of the present study is that it describes the frequency of requests for blood tests to assess hydration during the whole admission in large numbers of consecutive stroke patients. In our study, the frequency of testing ranged between 92% on day 0% and 18% on day 30. Not surprisingly, we found the number of tests per patient reflected greater stroke severity, a longer length of stay in hospital, and whether the blood test indicated dehydration. There were more tests showing dehydration between inpatient days 11 and 30, presumably because more patients being tested had blood tests showing dehydration previously or risk for dehydration.

A major limitation of this study is the lack of “gold standard” measure of dehydration. Although the U:C ratio is commonly used to assess hydration status, it is not a specific measure because it may increase in patients with gastrointestinal bleeding and other medical conditions that were not recorded in this study. The retrospective nature of the analysis means that we could not systematically study other clinical and laboratory hydration indices, medications, the presence of infection, diarrhea, vomiting, and comorbidities that might be associated with dehydration or at least an increased U:C ratio. Finally, outcomes measured at hospital discharge are not ideal because they are confounded by length of stay.

**Conclusions**

Dehydration appears to be common in hospitalized stroke patients and is associated with severe stroke and poor outcomes at hospital discharge. We suggest that focusing on interventions to reduce the frequency and duration of dehydration have the potential to improve patient outcomes after stroke.

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**Disclosures**

None.

**References**

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