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What is This?
Use of a Urine Color Chart to Monitor Hydration Status in Nursing Home Residents

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Kennith Culp, PhD, RN

To determine whether urine color, as measured by a color chart, might be a valid indicator of hydration status in frail nursing home residents, this study tested the associations between urine color and urine specific gravity. This is a descriptive correlational study set in seven nursing homes in eastern Iowa. Ninety-eight nursing home residents ≥65 years of age participated. Exclusion criteria for the study included: unstable congestive heart failure or diabetes, documented renal disease, hyponatremia (serum sodium < 135 meq/L), terminal illness, acutely confused/delirious or urinary tract infection at baseline, and gastrostomy-tube dependence. Weekly urine specimens were collected. Ucol was measured first, using a urine color chart. Usg was determined using the Chemstrip Mini UA Urine Analyzer. Week-by-week Spearman rank order correlations between urine color and specific gravity for the total sample (n = 98) ranged from $r_s = 0.3 - 0.7$, $p < .01$; the PROC mixed model was significant, $p < .01$. In subgroup analyses (n = 78), all females ($r_s = 0.67$, $p = .01$) and both males ($r_s = 0.53$, $p = .01$) and females ($r_s = 0.72$, $p = .01$) with adequate renal function (Cockcroft-Gault estimated creatinine clearance [CrCl] values of ≥50 ml/min) had significant associations between average urine color and average Usg. Females with mild renal impairment (CrCl between 30 and 50 ml/min) also had significant associations between Ucol and Usg ($r_s = .64$, $p < .01$). Ucol averaged over several individual readings offers another tool in assessing hydration status in Caucasian nursing home residents with adequate renal function measures by estimated CrCl values.

Key words: dehydration, urine specific gravity, creatinine clearance, aged

The frailty of nursing home residents has steadily increased since 1985. Currently, the mean number of activities of daily living (ADLs) with which residents require help is 4.4 out of 6, more than 50% of residents have mild to severe cognitive impairments, and 60% of residents are incontinent of urine (Sahyoun, Pratt, Dey, & Robinson, 2001). As a result, frail, older nursing home residents often cannot meet their hydration needs.

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needs autonomously. Consequences of inadequate fluid intake in these at-risk nursing home residents include dehydration, urinary tract infections, constipation, and acute confusion/delirium, which precipitate hospitalization and increased morbidity and mortality (Armstrong-Esther, Browne, Armstrong-Esther, & Sander, 1996; Mentes, Culp, Maas, & Rantz, 1999; Palevsky, Bhagrath, & Greenberg, 1996; Warren et al., 1994).

Ensuring optimum hydration for elderly individuals in long-term care settings is a complex process (Armstrong-Esther et al., 1996; Kayser-Jones, Schell, Porter, Barbaccia, & Shaw, 1999; Mentes & Iowa Veterans Affairs Nursing Research Consortium, 2000; Palevsky et al., 1996). Nursing home settings pose a particularly thorny problem because of the frailty of residents in these facilities and the small number of professional nurses available for ongoing hydration assessment and supervision of appropriate hydration interventions (Burger, Kayser-Jones, & Bell, 2000; Kayser-Jones et al., 1999). Furthermore, measurement of hydration status is imprecise. Twenty-four-hour intake and output recordings are not reliable or practical given the time and number of staff persons required to make the observations and complete the recording (Mentes & Iowa Veterans Affairs Nursing Research Consortium, 2000). Standard measures of dehydration, such as serum sodium, serum osmolality, or BUN/creatinine ratio require venipuncture, which is not as available in community nursing home facilities as in hospital settings. Furthermore, the hematological indices are later indicators of dehydration and therefore cannot serve as a warning system to alert staff to hydration problems when preventive measures could still be enacted to prevent frank dehydration. Urine indices, such as urine color (Ucol) and urine specific gravity (Usg), are more responsive to smaller changes in hydration status and are the first signs of impending dehydration (Francesconi et al., 1987). In addition, they are easily obtained and can be evaluated on site. Especially in nursing homes, it is beneficial to measure hydration status rather than dehydration when remedial interventions can be taken to prevent dehydration and its sequelae. Therefore, a simple, cost-effective clinical measurement of hydration status, such as urine color, that can be obtained by direct-care staff can be helpful in preventing dehydration through early detection.

**Urine Color as an Indicator of Hydration Status**

Darker urine color is accepted as an indicator of poor hydration status in individuals (Kavouras, 2002). Studies of younger servicemen and athletes have demonstrated a significant relationship between urine color, specific gravity, and osmolality as indicators of hydration status and a nonsignificant relationship with the hematological indices, such as serum sodium, osmolality, BUN, and creatinine ratio (Armstrong et al., 1998; Armstrong et al., 1994; Francesconi et al., 1987). These results support the notion that urine indices are sensitive to smaller changes in hydration status and that the homeostatic mechanisms of the body attempt to preserve cardiovascular function until increasing losses of total body water cannot be managed. Therefore, it is feasible that urine color could be used to detect early hydration problems.

A urine color chart developed by Armstrong and colleagues (1994, 1998) was found to be valid in younger athletes (Armstrong et al., 1998; Armstrong et al., 1994) and hospitalized elderly veterans (Wakefield, Mentes, Diggelmann, & Culp, 2002). Correlations between Ucol and Usg in young athletes ranged from .54 to .93. In the elderly veteran population, Ucol and Usg were also correlated (.57 at baseline, .59 at fasting); however, this veteran population was 99% male and individuals had varying acuity of illness, which limit the generalizability of results (Wakefield et al., 2002).

Questions remain about the utility of Ucol as a valid indicator of hydration status in elderly nursing home residents who have decreased renal function and comorbid medical conditions and take multiple medications, all of which can affect renal concentration abilities. Renal function, as measured by serum creatinine levels and creatinine clearance, is known to decline with age in men (Lindeman, Tobin, & Shock, 1985; Rowe, Andres, Tobin, Norris, & Shock, 1976). Few longitudinal studies have been conducted that include older women; however, recent reports indicate that creatinine clearance also decreases in both healthy and frail elderly women (Papaionnou et al., 2001; Sokoll, Russell, Sadowski, & Morrow, 1994). Serum creatinine levels rise in both sexes with increasing age, although men’s levels are higher than women’s at all ages (Papaionnou et al., 2001). Of significance for this study, poor renal function can cause decreased con-
centration abilities, affecting Ucol, which thus might not accurately reflect the specific gravity of the urine. Therefore, Ucol may only be helpful in monitoring hydration status in residents with better renal function. Our purpose for this project was to determine whether urine color, as measured by a color chart (Armstrong et al., 1998; Armstrong et al., 1994), is a valid indicator of hydration status in nursing home residents and to examine the effect of renal function on the relationship between Ucol and Usg.

Method

Data for this report were collected as part of an 8-week intervention study to evaluate the effectiveness of a hydration-management intervention to prevent acute confusion and urinary tract and respiratory infections in elders living in nursing homes (Culp, Mentes, & Wakefield, 2003; Mentes & Culp, 2003). An evaluative component of the intervention study included examining the participants’ urine for specific gravity and color on a weekly basis to assess compliance with the hydration intervention. Participants had serial measurements of urine color and specific gravity, with one to seven specimens collected during the course of the investigation. Using these specimens, we employed a descriptive-correlational design to evaluate whether Ucol was associated with Usg, a standard measure of hydration status.

Settings

Seven nursing homes located in eastern Iowa participated in the study. Five of the facilities had less than 120 beds, and two were Veteran Affairs facilities with more than 300 beds.

Sample

Each participant or his or her legal guardian gave written informed consent to participate in this study, which was approved by the Institutional Review Board of the University of Iowa and appropriate individuals at each nursing home. The sample consisted of 98 nursing home residents (53% female) with a mean age of 84 years ($SD = 8.4$, range = 63-101), who participated in the intervention study. Mean age of female participants was 86 years ($SD = 8.6$), with male participants slightly younger at 82 years ($SD = 7.7$).

Exclusion criteria for the study included (a) unstable congestive heart failure as documented by the participant’s primary care provider, (b) unstable diabetes as indicated by sliding-scale insulin use, (c) documented renal disease (serum creatinine $> 3.5$ mg/dL), (d) hyponatremia (serum sodium $< 135$ meq/L), (e) terminal illness by diagnosis or care documentation, (f) acute confusion at baseline, (g) urinary tract infection at baseline, and (h) gastrostomy-tube dependence. The extensive decision algorithm used to determine whether a participant exhibited acute confusion is described elsewhere (Mentes & Culp, 2003).

Data Collection Protocol

Demographic data, medical diagnoses, current medications, height, and weight were abstracted from each participant’s medical record. Although the participant’s body mass index (BMI) is recorded in the dietary records, we recalculated the BMI based on the resident’s most current weight at baseline.

As part of the overall protocol for the intervention study, trained research assistants collected baseline and weekly second-voided urine specimens to monitor hydration status by assessing Ucol and Usg. After collection, the specimen was placed in a clear test tube and held against a Ucol color chart with a white background. The chart has eight numbered colors ranging from pale straw to greenish brown (Armstrong et al., 1998; Armstrong et al., 1994). The number of the color (1-8) was used to code the Ucol (higher numbers indicate darker urine color). Any medications or foods that might alter Ucol were noted at the start of the study. Ucol was always measured first to reduce any bias that could occur if the Usg were known. Furthermore, the research assistants were instructed to perform every color measurement under the same lighting conditions and to use the decision rule of rating at the highest number if the Ucol fell between two colors on the chart. Interrater reliability was established at the beginning of the study using four colored-water specimens that had been rated by the project director. Research assistants at the research sites rated the specimens using the rules previously mentioned. Kappa statistics ranged from 0.42 to 1.00 for the raters.
Usg was determined by using the Chemstrip Mini UA Urine Analyzer (Boehringer Mannheim Corporation, Indianapolis, IN) along with Chemstrip 10M UA urine test strips. The specific gravity readings obtainable from this analyzer ranged from 1.000 to 1.030 in .005 intervals. The Chemstrip Mini UA analyzer is a semiautomated analyzer intended for in vitro semiquantitative determination of urine analyses (Boehringer Mannheim Corporation, 1994).

Data collected on food intake and medications demonstrated that both had a minimal effect on urine color. Nursing home residents do not often get the fresh fruits (berries, rhubarb) or vegetables (beets, carrots, fava beans) that are known to discolor urine. Although there are medications that can alter the color of urine, only a few were prescribed for our participants, including aspirin (23%), ibuprofen (5%), levodopa (1%), multivitamins (35%), nitrofurantoin (1.4%), phenytoin (2.8%), and warfarin (10%). All of the drugs listed except nitrofurantoin are reported to discolor the urine to a reddish color (Micromedex, 2003), which is readily identifiable. As per protocol, a specimen exhibiting this color would be discarded. For some drugs, such as levodopa, the discoloration occurs if the urine specimen is left standing. Because we evaluated Ucol at the time of collection, we believe that the medications had little effect. Multivitamin use has the potential to discolor the urine in one of the directions of interest, that is, to make the urine more yellow in color. Therefore, a t test of mean urine color was conducted on participants who were taking multivitamins (mean Ucol = 2.3) and those who were not (mean Ucol = 2.0). The results demonstrated no significant differences between the groups (Ucol t<sub>96</sub> = −1.42, p = .16).

Data Analysis

All data were entered and stored in a Windows 1998 Access database, formatted and imported into the Statistical Package for Social Sciences (SPSS) Version 10 and Statistical Analysis System (SAS) 11.0 for analysis. Descriptive statistics were used to analyze demographic data. Preliminary analysis was accomplished by doing a week-by-week correlation between Usg and Ucol using Spearman rank order correlations and then using the SAS mixed procedure (PROC mixed), which averaged values over the 7 weeks taking repeated measures into account. The PROC mixed procedure is robust in the face of missing data. Subgroup analyses (n = 78) by gender and Cockcroft-Gault estimated creatinine clearance (CrCl) were conducted using Spearman rank order correlation coefficients calculated for Ucol ratings and Usg measurements averaged for each participant over the study period. Average values of Usg and Ucol were used because they yield a more normative value for the individual than any one value.

Results

Analyses of the total sample (n = 98) included week-by-week Spearman rank order correlations of Ucol and Usg that were significant at baseline and subsequent weekly evaluations (see Table 1). A PROC mixed model was significant (p < .001). Because the correlation between Ucol and Usg ranged between rs = .3 and .7, subgroup analyses (n = 78) examining the effect of gender and renal function on the relationship between mean Ucol and mean Usg were conducted.

Subgroup Analyses

Demographics

Subgroup analyses of the correlation between Ucol and Usg by gender, creatinine level, and estimated CrCl were conducted on the 78 participants who had complete data; 40 (51%) females and 38 (49%) males were included in these analyses. Of these 78, 98% were Caucasian. There were no statistically significant gender differences in age, medically diagnosed conditions, number of prescribed medications, or baseline

<table>
<thead>
<tr>
<th>Time</th>
<th>Spearman Rank Order Correlation</th>
<th>Significance</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>.51</td>
<td>.000</td>
<td>90</td>
</tr>
<tr>
<td>Week 2</td>
<td>.48</td>
<td>.000</td>
<td>92</td>
</tr>
<tr>
<td>Week 3</td>
<td>.31</td>
<td>.004</td>
<td>86</td>
</tr>
<tr>
<td>Week 4</td>
<td>.39</td>
<td>.000</td>
<td>77</td>
</tr>
<tr>
<td>Week 6</td>
<td>.39</td>
<td>.009</td>
<td>44</td>
</tr>
<tr>
<td>Week 7</td>
<td>.64</td>
<td>.001</td>
<td>25</td>
</tr>
<tr>
<td>Week 8</td>
<td>.71</td>
<td>.001</td>
<td>19</td>
</tr>
</tbody>
</table>
serum creatinine levels. Mean Cockcroft-Gault estimated CrCl values were lower for females (48 ml/min) than for males (59 ml/min), in fact, 33% of female versus 58% of male participants had adequate renal function defined as a CrCl ≥ 50 ml/min (Couchoud, Pozet, Labeeuw, & Pouteil-Noble, 1999; Papaionnou et al., 2001) (see Table 1). The participants had BMIs in the high-normal to overweight range. Average BMI for the male participants in the study was 25.9; for female participants, it was 27.1. The prevalence of diagnosed medical conditions that can affect renal function such as diabetes mellitus type II, hypertension, and renal insufficiency was 17%, 33%, and 3%, respectively.

Trends in clinical characteristics of participants show that those with adequate renal function were younger, had lower serum creatinine values, and had higher BMIs (see Table 2). Men had more medical diagnoses than females at each level of renal function.

### Urine Color and Specific Gravity

Spearman rank order correlation coefficients were calculated between Usg and Ucol averaged for each participant over the course of the study. The overall subgroup correlation between Usg and Ucol was significant (r = .48, p < .01). Given the demographic differences between males and females at baseline, correlations were also calculated using a Spearman rank order coefficient and stratifying the sample by gender and Cockcroft-Gault estimated CrCl values with cutoff points for CrCl values of ≤ 30 ml/min (moderate renal impairment), between 30 and 50 ml/min (mild renal impairment), and ≥ 50 ml/min (adequate function) as defined by Papaionnou and colleagues (2001). Based on these analyses, female participants (r = .67, p < .01), but not male participants (r = .17, ns), had a significant relationship between Ucol and Usg. Furthermore, females with both mild renal impairment and adequate renal function had significant correlations between Ucol and Usg, whereas only male participants with adequate renal function showed significant correlations (see Table 3).

### Discussion

The relationship between Ucol and Usg is preserved into old age in elders who have better renal function as measured by Cockcroft-Gault estimated CrCl. Although there were small numbers of participants across renal function groups, particularly in the moderate impairment group, it appears that there is a gender difference in the relationship between Ucol and Usg. The correlation between Ucol and Usg in frail elderly female residents with better renal function approaches the relationship that Armstrong and colleagues found in young athletes. In our study, elderly females with mild insufficiency to adequate renal function had correlations of .64 and .72, respectively, versus correlations ranging from .54 to .93 in young adult athletes (Armstrong et al., 1994). However, this correlation does not hold true for the male participants in this study, where there is a weaker significant relationship between Ucol and Usg only in those with adequate renal function.

**Table 2. Comparisons of Mean Clinical Characteristics of Participants by Creatinine Clearance Group (n = 78)**

<table>
<thead>
<tr>
<th>Creatinine Clearance Group</th>
<th>Age (SD)</th>
<th>Number of Medications (SD)</th>
<th>Number of Medical Diagnoses (SD)</th>
<th>BMI (SD)</th>
<th>Serum Creatinine (mg/dL) (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adequate function (≥50 ml/min)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male (n = 22, 58%)</td>
<td>77 (7.6)</td>
<td>6 (2.5)</td>
<td>7 (2.2)</td>
<td>26.9 (5.9)</td>
<td>0.94 (0.25)</td>
</tr>
<tr>
<td>Female (n = 13, 33%)</td>
<td>77 (6.5)</td>
<td>5 (1.8)</td>
<td>5 (2.1)</td>
<td>28.5 (5.0)</td>
<td>0.77 (0.17)</td>
</tr>
<tr>
<td>Mild impairment (between 30 and 50 ml/min)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male (n = 13, 34%)</td>
<td>87 (4.1)</td>
<td>5 (2.0)</td>
<td>7 (2.9)</td>
<td>24.7 (3.0)</td>
<td>1.3 (0.21)</td>
</tr>
<tr>
<td>Female (n = 20, 50%)</td>
<td>87 (6.8)</td>
<td>6 (3.1)</td>
<td>6 (3.1)</td>
<td>27.0 (6.9)</td>
<td>1.0 (0.24)</td>
</tr>
<tr>
<td>Moderate impairment (≤30 ml/min)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male (n = 3, 7%)</td>
<td>87 (5.3)</td>
<td>9 (3.6)</td>
<td>10 (1.5)</td>
<td>24.0 (0.95)</td>
<td>1.7 (0.12)</td>
</tr>
<tr>
<td>Female (n = 7, 17%)</td>
<td>94 (5.1)</td>
<td>3 (1.9)</td>
<td>7 (2.5)</td>
<td>25.0 (6.8)</td>
<td>1.4 (0.47)</td>
</tr>
</tbody>
</table>

Mentes et al. / Use of Urine Color Chart
The renal function of our sample of nursing home residents is similar to the description of Canadian nursing home residents given by Papaionnou and colleagues (2001). Forty percent of our male participants versus 44% in the Canadian sample, and 67% of our female participants versus 70% in the Canadian sample, had some renal impairment as evidenced by a CrCl < 50 ml/min. Although this is a high percentage of individuals classified with renal impairment, little is known about the aging-disease interface with kidney function in elders older than 85 years (Papaionnou et al., 2001; Wieczorowska-Tobias, Niemir, Guzik, & Mossakowska, 2004). Equations for estimation of CrCl have been developed specifically to monitor renal failure in persons with known kidney disease versus prediction of age-related kidney function in older individuals (Couchoud et al., 1999). Equations for estimation of CrCl have been developed specifically to monitor renal failure in persons with known kidney disease versus prediction of age-related kidney function in older individuals (Couchoud et al., 1999). Normal CrCl values vary considerably in old age. For example, in males and females aged 60 to 69 years, CrCl is 54 to 98 ml/min and 45 to 75 ml/min, respectively, whereas in males and females aged 90 to 99 years, CrCl is 26 to 44 ml/min and 26 to 42 ml/min, respectively (Wallach, 2000). Therefore, despite low CrCl values, this older nursing home population may be exhibiting age-related changes rather than renal disease per se.

These findings, with noted caveats, lend beginning support to the regular use of a urine color chart for assessment of hydration status in nursing home residents with better renal function as defined by CrCl values. Because toileting is a major component of personal care delivered to nursing home residents, it seems reasonable that a Ucol evaluation could be obtained for residents who can be toileted. Certified nursing assistants can be taught to use the urine color chart and to report these findings. This is one way to structure the health care data that are needed to provide adequate hydration care and prevent episodes of dehydration.

Several pointers should be considered in using the urine color chart. First, it is important to measure several specimens for baseline readings. Subject-specific reference ranges for biochemical indices in elders based on serial measurements in an individual have been advocated as more accurate than population-based reference ranges, which are often established using younger adults (Olde Rikkert, van’t Hof, Baadenhuysen, & Hoefnagels, 1998). Second, measuring the first or second voided specimen of the day ensures that food and shorter acting pharmaceuticals, such as the B vitamins, that may potentially discolor the urine will be minimized.

Despite the encouraging results from this study, several limitations need to be discussed. First, the assessment of Ucol remains subjective despite attempts to make it as objective a measure as possible, as evidenced by interrater reliabilities of the research assistants measuring the Ucol ranging from average to good. Furthermore, although we made every attempt to assess the influence of food and medication on Ucol, there may be individual responses to food or medications for which we could not account. We did not include the analysis of urine specimens that were grossly discolored on visual inspection.

Second, the majority of our participants were Caucasian, which limits generalizations of these findings to other cultural groups. Elders of African American and Latino descent have higher prevalence rates of diabetes, hypertension, and heart disease, which are known to affect renal function and the consequent use of a color chart to evaluate urine (Salive et al., 1995).

The nursing home participants included in this study were continent of urine or were able to give a specimen when requested. The prevalence of urinary incontinence in nursing home residents varies across nursing homes and is related to the frailty of the residents, the prevalence of dementia, and staffing levels, to name a few factors. Widespread use of incontinent garments is often the first line of treatment for incontinence, which limits the use of the urine color chart, as

<table>
<thead>
<tr>
<th>Subsample (n = 78)</th>
<th>Correlations for Urine Specific Gravity and Color by Gender and Renal Function (n = 78)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>0.48**</td>
</tr>
<tr>
<td>Male (n = 38)</td>
<td>0.17</td>
</tr>
<tr>
<td>Female (n = 40)</td>
<td>0.67**</td>
</tr>
<tr>
<td>Moderate impairment (≤30 ml/min)</td>
<td>ns</td>
</tr>
<tr>
<td>Male (n = 3)</td>
<td>ns</td>
</tr>
<tr>
<td>Female (n = 7)</td>
<td>ns</td>
</tr>
<tr>
<td>Mild impairment (between 30 and 50 ml/min)</td>
<td>ns</td>
</tr>
<tr>
<td>Male (n = 13)</td>
<td>ns</td>
</tr>
<tr>
<td>Female (n = 20)</td>
<td>0.64**</td>
</tr>
<tr>
<td>Adequate function (≥50 ml/min)</td>
<td></td>
</tr>
<tr>
<td>Male (n = 22)</td>
<td>0.39*</td>
</tr>
<tr>
<td>Female (n = 13)</td>
<td>0.72**</td>
</tr>
</tbody>
</table>

*p < .05; **p < .01, Spearman rank coefficients.
it has not been validated for assessing urine color taken from incontinent garments.

Prevention of dehydration remains a priority for nursing home staff members. The use of a urine color chart during everyday processes of care is a low-intensity and low-cost method to assess hydration status that can help the staff to intervene early, thus averting the development of dehydration and its sequelae. The current ethnic makeup of our nursing homes consists largely of Caucasian women (Federal Interagency Forum on Aging-Related Statistics, 2000). Therefore, it is encouraging that the urine color chart may have greatest utility in assessing hydration status in nursing homes where most of the residents are women.

References


