abstract

Homeostasis of fluid balance is an important prerequisite for healthy aging. The high prevalence of disturbances of fluid balance among older adult patients has triggered clinical research on age- and disease-related changes in water homeostasis. Empirical findings on risk factors of dehydration and on diagnostic and therapeutic strategies are reviewed in this paper. No single measure has proved to be the gold standard in the diagnosis of dehydration. Diagnosing dehydration and monitoring fluid balance requires repeated measurements of weight, creatinine, and physical signs such as tongue hydration. Rehydration and prevention requires fluid on prescription (> 1.5 litre/day), and the route of fluid administration depends on the acuteness and severity of clinical signs.

Keywords: older adults, dehydration, fluid therapy, risk factors, diagnosis

Dehydration in Geriatrics

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Introduction

There is substantial evidence to show that aging causes changes in body water composition, and that renal function and thirst perception on average decline among older adults.[1-3] These three factors account for the prevalence of dehydration among the older adult population. In one American study, dehydration was diagnosed in 6.7% of hospitalized patients age 65 and over, and 1.4% had dehydration as the principal diagnosis.[4] Prospective studies in long-term care facilities (LTCs) showed that residents were dehydrated in 50% of the febrile episodes and that 27% of the LTC resident population referred to hospitals was admitted due to dehydration.[5,6] Dehydration also proved to be very common in community-dwelling older adults.[7] Dehydration is not only a common but also a very serious condition in older adults. Mortality of patients with dehydration is high if not treated adequately and in some studies exceeds 50%.[6,8] In terms of morbidity, several studies showed an association between high degrees of dehydration and poor mental function.[9,10] Others found that dehydration was a significant risk factor for developing thrombo-embolic complications, infectious diseases, kidney stones, and obstipation.[11,12] These findings demonstrate the importance of timely diagnosis and adequate treatment of dehydration to reduce its serious effects on older adult patients.

Unfortunately, an early diagnosis is often difficult because the classical signs of dehydration may be absent or misleading in an older patient. In this article, we review the most important age-related risk factors for dehydration because they may help to identify older adults most at risk for dehydration. Next, we summarize recent developments in the diagnosis, prevention, and treatment of dehydration in clinical practice.

Definitions

In 1995 the American Medical Association warned its members that there exists no absolute definition of dehydration, and that the signs and symptoms of dehydration may be vague, deceptive, or even absent in older adults.[23] Dehydration can be defined as a clinically relevant decrease of an individual's optimal Total Body Water (TBW) amount and may occur with or without loss of electrolytes.

Risk Factors

Hippocrates stated that older adults showed a general decline in total body water, and even declared that this loss of body water was the cause of all symptoms of aging. Recent cross-sectional and longitudinal studies in healthy older adult populations have unequivocally confirmed this classical dogma of a decrease in body hydration with increasing age, but only in the sense of a decrease in the absolute amount of TBW.[13] However, it is difficult to accurately predict body hydration of individual older adults because of the large interindividual differences in body hydration. Nevertheless, the mean

Table 1: Risk Factors for Dehydration among Older Adults

Normal changes of aging	Age >85 years Female Low total body water, low body weight Decline in maximal renal water- and salt-conserving capacity Lower responsiveness of thirst
Functional	Poor mobility Comprehension/communication problems Oral intake <1500 ml per day Hand dexterity/body control problems Self-neglect
Environmental	Hospitalization Insufficient caregivers/Understaffed institution Insufficiently skilled caregivers/staff Summer (hot weather) and winter (too high temperature in the home due to central heating) Isolation
Disease-related	Having Alzheimer's disease ≥5 chronic diseases Fluid loss by diarrhea, fever, vomiting, bleeding, fever, tachypnea, artificial ventilation, polyuria, decubitus, burns Reduced intake by dysphagia, anorexia, acute confusion, depression, dementia Previous episode of dehydration, fear of incontinence, unexplained weight loss
Iatrogenic	Drug-related: laxatives, diuretics, lithium, hypnotics High protein intake (oral/enteral/parenteral) Dietary restriction of fluids, salt Diagnostic procedures requiring fasting

Source: Modified from Olde Rikkert MGM, et al.[45]

decrease of TBW with aging is an important risk factor for the occurrence of dehydration, though it is largely unknown how the decline in TBW affects hydration of individual organs and tissues. The skin often seems to be much drier among older adults. This is only partly explained by the small decrease in water content of the stratum corneum of the skin.[14] Other histopathological changes must contribute substantially to the dry appearance of old age skin.

The severity of dehydration depends more on the relative than on the absolute loss of total, intracellular, and extracellular water.[4] The lower an individual's body weight and optimal amount of TBW, the sooner the loss of a relatively small amount of body water will cause symptoms and signs of dehydration. This is the reason why the reduction in total body water as an unavoidable part of aging is an intrinsic risk factor for the development of dehydration among older adults. Reduced thirst and renal water conservation capacity are also risk factors, probably associated with aging per se.[5,7,8,15] If older adults are functioning independently they fulfill their daily needs for water easily with bouts associated with their meals and social drinks.[6,16] However, with increasing age a substantial number of older adults (up to 25% of persons age 85 and over) drinks less than 1 litre of fluids per day.[17] The limited capacity of homeostatic mechanisms to maintain fluid balance only becomes important when fluid balance is at risk.

Environmental and disease-related risk factors for dehydration have a very high prevalence among older adults. Lavizzo-Mourey identified the most important risk factors for dehydration in a large prospective study on a LTC population.[5] Being over 85 years old and female, having five or more chronic diseases, taking five or more kinds of medication, and being bedridden were significant risk factors in developing a moderate degree of dehydration. In the case of severe dehydration the odds ratios for these risk factors were very high. The weather (particularly hot weather), inability to feed oneself, poor mobility, and a low level of care were also significant but less prominent risk factors. Having Alzheimer's disease is an additional risk factor after having controlled for all these factors, because it is associated with increased dependence on others for sufficient water intake and physiological changes such as a low arginine vasopressine (AVP) level.[18] Individuals in an AVP–deficient state are prone to dehydration because of having a poor water concentrating capacity. Lavizzo-Mourey's risk factors are presented in Table 1, together with the most important causes of hypernatremic dehydration.[13,19-23] These risk factors should be important triggers to alert physicians and nurses to the possibility of dehydration in older adult patients.

Diagnosing Dehydration

Classical signs of dehydration such as loss of skin recoil time, increased thirst, and orthostatic hypotension have a low sensitivity in older adults (60–75%).[24–26] Specificity of abnormal skin recoil time at the forearm or subclavicular region, and a dry oral mucosa is a better indicator (80–90%) and may be used to rule in the diagnosis of hypertonic dehydration.[25] In the older adult, dehydration often causes atypical symptoms such as confusion, constipation, or less frequently fever or

Table 2: Important Clues from Medical History, Physical, and Laboratory Examinations of Older Adult Patients in the Initial Assessment of Dehydration*

Clue/Symptom/Sign Deficiency	Water Deficiency	Water + Electrolyte Deficiency
Medical history	Recently >3% weight loss Impaired water intake Increased perspiration (fever, tachypnea, heat)	Recently >3% weight loss. Vomiting, diarrhea, diuretic drug use, diabetes, bleeding
Physical Examination		
Tongue dryness	+	+
Longitudinal tongue furrows	+	+
Dry mucous membranes mouth	+	+
Upper body muscle weakness	+	+
Confusion	+	+
Speech difficulty	+	+
Sunken eyes	+	+
Blood pressure	=/_	__
Pulse rate	=/_	__
Laboratory tests		
Serum creatinine	_	_
Serum urea	_	__
Tonicity	__	=/_
Urinary output	_	_/=/_
Urinary sodium concentration	_	_/=/_

* With and without concomitant loss of electrolytes
Legend for Table 2: +, present; _, increased; __, highly increased; _, decreased; __, highly decreased; =, unchanged.

falls. Confusion, constipation, and falls are part of the very frequently occurring "geriatric giants," and therefore their specificity as a single parameter is far too low to be useful in diagnosing dehydration.

Three forms of dehydration can be distinguished on the basis of the plasma tonicity: hypertonic, isotonic, and hypotonic dehydration. Many studies on dehydration are limited to hypertonic dehydration. This diagnosis is easy to make by laboratory tests and unequivocal (e.g., serum sodium levels >150 mmol/L or serum osmolality >300 mosmol/L), but neglects the frequently occurring isotonic and hypotonic dehydration. Isotonic dehydration results from a balanced loss of water and electrolytes (e.g., by vomiting and diarrhea) and hypotonic dehydration results when loss of electrolytes exceeds water loss (e.g., by overuse of diuretics). The prevalence of isotonic and hypotonic dehydration among older adults has never been studied systematically, probably because of the difficulties in diagnosing them correctly. A proper diagnostic approach to dehydration in clinical practice should be sensitive and specific for all three forms of dehydration.

Important Symptoms and Laboratory Measures

The initial assessment of fluid status of an older individual is often very difficult. It should answer not only whether there is dehydration but, if the patient is dehydrated, it should also describe the type of dehydration, its development in time, and its severity. Many studies have been performed in search of a single measure to determine dehydrated and not-dehydrated or euvolemic patients. However, decreased intraocular pressure,[27] absent axillary sweating,[28] increased plasma specific gravity, increased cerebrospinal fluid protein, or urinary colour have not fulfilled this need.[29–30] The diversity in dehydration episodes and the heterogeneity of the older adult population rules out a one-dimensional approach to diagnosing dehydration. It may be more valuable to select a set of clinical signs and symptoms and laboratory measures that have proved to be useful in the discriminative diagnosis of dehydration with and without salt depletion in older adults (Table 2).[31] Gross *et al.* found that the seven signs that correlat-

ed well with dehydration severity (Kendall's tau ≥ 0.35, p<0.01), but were unrelated to patient age, (Kendall's tau ≤ 0.20, p>0.05) were the most valuable indicators of dehydration in older adults.[32] A problem with Gross's seven signs is that there remains some subjectivity in assessing them; therefore, a cardiovascular assessment of blood pressure and pulse rate should also be included. There is no scientific evidence for the widely used clinical guideline that loss of body water, i.e., water loss without concomitant loss of electrolytes, is more likely to result in confusion among older adults than combined the loss of salt and water. As suggested by the very high prevalence of acute confusional states, some older adult patients may become easily confused by every disturbance of fluid balance, whatever its nature.

Traditionally, serum creatinine, blood urea nitrogen (BUN), and the BUN/creatinine ratio are advocated as useful laboratory measurements in detecting dehydration and other prerenal pathology.[33] Creatinine has proven to be the most sensitive measure.[34] In evaluating fluid balance to detect dehydration in older adults who are already known, for instance in long-term care, repeated measurements of a few laboratory variables are probably sufficient. Body weight proved to be most responsive to changes in hydration.[35]

Prevention and Treatment

It has been demonstrated that when older adults know that they should not trust thirst but should drink because it is healthy for them, water intake increases above the minimum intake of 1700 ml per day.[17] For calculating the minimum amount of fluid per day, a formula based on body weight is recommended: 1500 ml is the minimum water intake with 15ml fluid per kg to be added for the actual weight minus 20 kg. This formula can be used for older adults who are normal weight, underweight, or overweight.[36]

Geriatric nurses and caregivers play a crucial role in the prevention of dehydration, as it has been shown that verbal prompting to drink between meals was effective in improving fluid intake in more cognitively impaired residents of LTCs.[37] Less cognitively impaired residents increased their fluid intake if they were given the beverages they preferred. The increase in fluid consumption did not occur at the expense of reduced consumption of food or fluid during meals. Participants with higher BMI values showed larger increases in their fluid consumption, but underweight participants (BMI <20) also showed a significant increase in their fluid consumption. Although the fluid intake increased by these feeding interventions, the food and fluid intake of the majority of the participants was still inadequate (≤75%).[37] Long-term care residents, for example, eat far from 100% of their meals, whereas almost 80% of the total daily fluid comes from fluid intake associated with meals. Patients consuming less than 50% of their meals are at high risk for dehydration. Caregivers should be aware of and anticipate this hazard.[36]

Other dehydration prevention measures include having water easily reachable throughout the day, encouraging drinking water by repeating self-care actions like brushing teeth, allowing adequate time and supervision during meals, encouraging family members to participate in feeding, and registering fluid intake.[38] Taking medication with fluid should be promoted. One study showed that LTC residents receiving medication consume significantly more fluid during nonmeal feedings than residents without medication.[36] For community-dwelling older adults dehydration may be prevented by educating them and their families or caregivers on the importance of hydration and the risk factors for dehydration.[39]

Key Points

- Dehydration has a high incidence accompanied with a mortality of up to 50% if not treated adequately in older adults 65 years and over.
- Important risk factors for dehydration are decline of total body water (TBW), reduced thirst, and renal water conservation capacity, which are phenomena associated with increasing age
- Signs and symptoms of dehydration may be vague, deceptive, or even absent in older adults.
- Diagnosing dehydration and monitoring fluid balance requires repeated measurements of weight, creatinine, and physical signs such as tongue hydration.
- Dehydration prevention measures: encouraging older adults to drink at least 1.5 litre per day and to finish their meals, prompting to drink between meals, optimize compliance of this regimen by giving fluid and food as preferred, and by registering fluid intake.

Treating the Frail Older Adult

Frail older adults with high risk of dehydration should take water specifically in amounts prescribed by their physician. Rehydration methods depend on the severity and type (isotonic, hypotonic, or hypertonic) of dehydration, as well as the availability of facilities such as intravenous procedures or hypodermoclysis. In general, severe hypernatremic dehydration with decline in consciousness warrants hospitalization. Rate and amount of rehydration volume needed is beyond the scope of this paper. If rehydration can be restored more gradually, because of less alarming and only mild hemodynamic symptoms and signs, oral repletion is highly preferable. Coffee and alcoholic drinks as well as fluids with high protein intake should be avoided because of their diuretic effects. Enteral feeding tubes are sometimes needed if water and nutritional balance must be restored. Ethical considerations must take place before starting tube feeding in case of a severe chronic disease (i.e., demen-

tia) at the end stage of life. Hypodermoclysis has been undervalued for a long time, but it is an evidence-based low cost therapy in geriatrics, with only small chances for adverse effects.[40] Approximately 3 litres of fluid can be given in a 24-hour period at two separate sites. Because of its safety and ease of administration, hypodermoclysis is a useful alternative to intravenous administration.[41] It is equally as well accepted by older adult patients as intravenous therapy. Additionally in confused patients and those in whom IV punctures are difficult to achieve, it represents the far superior method.[42] Hypodermoclysis can be set up and administered by nurses in almost any setting so that hospital admission may be avoided.[41] In periods of increasing risk for dehydration (starting a diuretic, diarrhea, vomiting, dependence by wrist fracture, or lithium therapy), physicians and other health professionals should take notice of water balance and prescribe and safeguard a minimum intake of 1.5 litres. In case of high body temperature (fever) or a hot climate with low humidity, fluid loss through sweat is increased. Apart from water replacement, it is essential to be aware of salt depletion.[43] In a recent randomized controlled trial we showed that in older men, the advice to increase fluid intake by 1.5 litres had no negative side-effects, but increased daily water turnover with approximately 1 litre.[44] Therefore the general advice to safeguard daily water intake in frail older adults at risk for dehydration by prescribing them an increased water intake especially in a period of increased water turnover can probably be carried out safely.

Conclusion

Recent findings on the effect of age on body hydration and on diagnosing dehydration confirm classical notions in medicine, which state that aging results in loss of body water and that dryness of the body is very difficult to assess. In the development of gerontology water conservation has served as a very useful model to study the physiology of aging. The age-related failure of homeostasis to compensate stressful disturbances has been demonstrated very clearly in disturbances of fluid balance. An important task for geriatricians is to increase their alertness for disturbances of fluid balance and to improve early detection of dehydration. The enormous impact of dehydration on older adults in terms of mortality, morbidity, and health care expenditures warrants continuous clinical and research efforts on this topic. More data are needed to determine how the mean loss of total body water with age affects individual organs, and how organ function is affected in pathological dehydration. Can prevention of recurrent dehydration contribute to preservation of renal function or even brain function? There are a lot of very relevant clinical questions left to be studied, without being seduced by the search for the one and only accurate clinical sign of dehydration. The large variability in the way different organs are affected by dehydration will cause dehydration symptoms to remain atypical in older adults, requiring the full intellectual and diagnostic efforts of current and future geriatricians.

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