Real-Time Urinary Electrolyte Monitoring as a Novel Clinical Tool for Diuretic Responsiveness Assessment

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Introduction

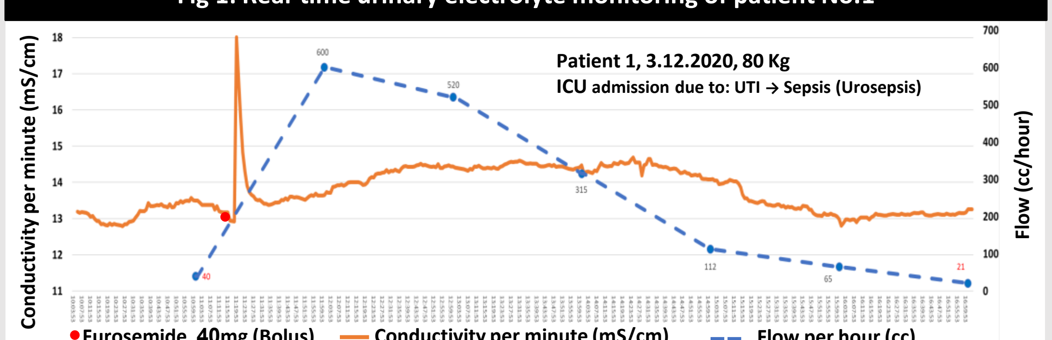
The term "urine electrolytes" is generally used to indicate urine concentrations of sodium, potassium, and chloride excreted by the kidneys. Those values reflect the balance between glomerular filtration, tubular secretion, and reabsorption of water and solutes, which can vary significantly under different pathophysiological and treatment conditions (1).

While diuretics are used in approximately 50% of ICU admissions, their efficacy remains unclear (2,3). Administration of low-dose Furosemide modifies urinary electrolyte excretion rates, in relation to the ongoing proximal tubular activity, by its inhibitory action on Henle's loop. Therefore, monitoring the concentration of urinary electrolytes would indicate the Furosemide impact and may provide a new and rapid method for testing its efficacy. *RenalSense* has developed a novel urine conductivity monitoring system that continuously monitors the concentration of urine electrolytes in real-time, along with Urine Output (UO). The aim of this study was to evaluate whether and how urine conductivity monitoring can help in assessing diuretic responsiveness.

Materials and Methods

The conductivity monitoring system was connected to 24 patients who were admitted to the Assuta Ashdod ICU. UO and electrolyte measurements were continuously recorded, before and after diuretic administration. Average age was 65.3 years, 12 males and 12 females. The median duration of sensor connection per patient was 3 days (STDEV 1.82), total of 74 connection days. Fourteen patients received diuretics for a cumulative total of 41 days. In 51% of the days the patients received Furosemide bolus, while in 49% of the days patients received a continuous IV drip of Furosemide or Metolazone.

Fig 1: Real-time urinary electrolyte monitoring of patient No.1

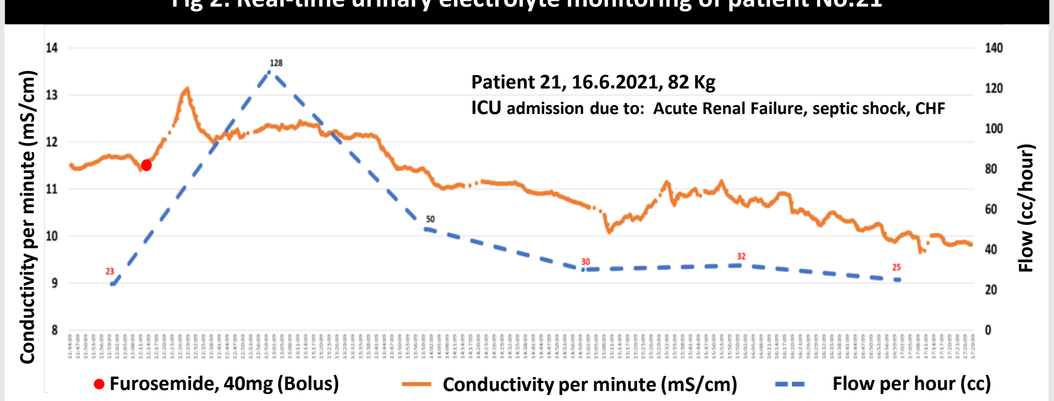


POSITIVE DIURETIC RESPONSE

Furosemide administration first caused a significant increase in conductivity and then a sharp rise in UO

Net fluid balance 6 hours <u>prior to</u> Furosemide administration: +245.7 cc
Net fluid balance 6 hours <u>after</u> Furosemide administration: -528.9 cc

Fig 2: Real-time urinary electrolyte monitoring of patient No.21



POOR DIURETIC RESPONSE

Furosemide administration first caused a minor increase in conductivity and then a minor rise in UO.

Net fluid balance 6 hours <u>prior to</u> Furosemide administration: -242.2 cc
Net fluid balance 6 hours <u>after</u> Furosemide administration: -53 cc

Urine electrolytes can indicate Furosemide response <u>within minutes</u>.

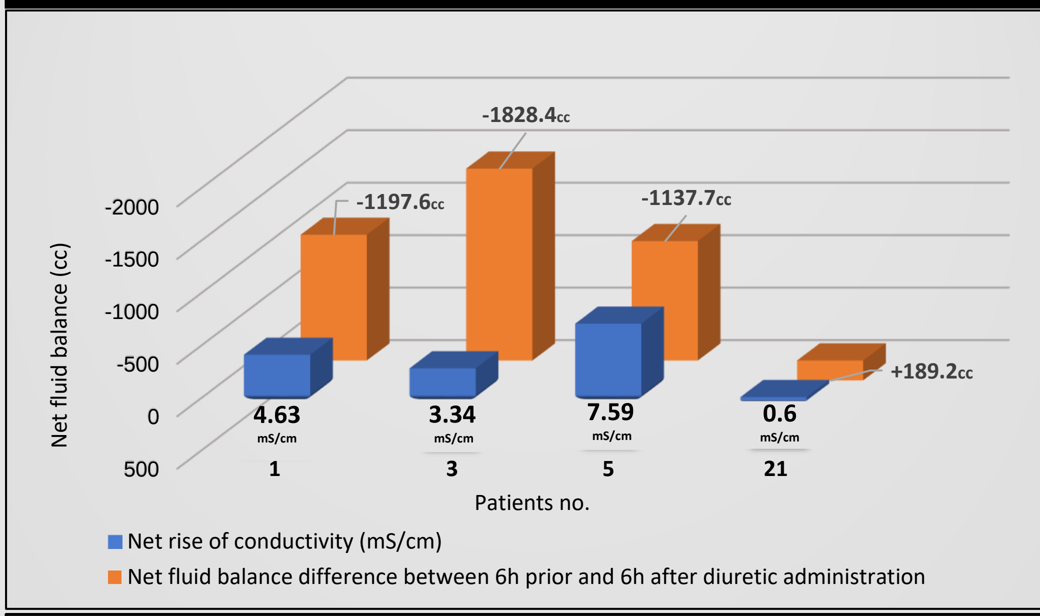
Results

Thirteen days of bolus Furosemide administration were analyzed. Of these, on 12 days, urine electrolyte elevation was seen immediately after the Furosemide administration, followed by a UO increase. The average increase of conductivity observed was 5.16 mS/cm ±1.99. The average conductivity value before diuretic administration was 10.73 mS/cm ± 2.12, therefore the average increase of conductivity was more than 50% higher than the initial value, prior to Furosemide administration.

While comparing the net fluid balance (FB) 6 hours before vs. 6 hours after diuretic administration, we observed an average <u>increase</u> of 734 cc ± 569 in <u>net-negative</u> FB. Hence, during days in which diuretic administration led to immediate increase of conductivity (i.e., an average of over 50% above the value before diuretic administration), a significant rise of net-negative FB was observed. The same trend was observed for 1 hour pre and post diuretic administration.

In one day of the 13, however, there was only a minor elevation in the urine electrolyte level (0.6 mS/cm), followed by a minor increase of UO. In this case, there was a <u>decrease</u> of 189cc, when comparing the <u>net-negative</u> FB 6 hours after diuretic administration to 6 hours before diuretic administration. Thus, in every case where there was a significant increase in net negative FB it followed a significant increase in conductivity. Similarly, in the solitary case where there was only a minor increase in net negative FB, it followed a minor increase in conductivity. These findings suggest that conductivity elevation can serve as a good predictor of diuretic response.

Fig 3: Conductivity elevation after Furosemide administration vs. the change of net fluid balance



Patients no. 1, 3 and 5 showed a significant rise of conductivity immediately after Furosemide administration. For all three patients, a substantial <u>increase</u> of net negative fluid balance was also observed.

For patient no. 21, a minor rise of conductivity immediately after Furosemide administration and a <u>decrease</u> of net negative fluid balance was shown.

The change of conductivity was calculated by the difference between conductivity measured one minute prior to Furosemide administration and several minutes after.

The change of net negative fluid balance was calculated by the difference between net fluid balance 6 hours prior to Furosemide administration and 6 hours afterwards.

Conclusions

The conductivity monitoring system provides a new tool for fluid management and diuretic use response . Continuous real-time measurements of urine electrolytes can also improve Acute Kidney Injury (AKI) classification and can assist in tailoring patient diuretic and hemodynamic therapies. Further clinical trials are required to firmly establish the correlation between urine electrolyte level and diuretic responsiveness.

References

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