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Problems with thoracic impedance monitoring in haemodialysed patients – our own experience

Hydration state is a well known problem in hemodialysis patients. There are some methods which are helpful in assessing proper target weight – such as vena cava collapsibility index obtained by ultrasound examination, the diameter of right atrium measured by echocardiography, or biochemical parameter like c-GMP estimation (2, 5, 8, 9). There were studies with computed tomography estimation or magnetic resonance of the thorax, detecting hydration of lung tissue, which correlates with hydration state (10, 11). But none of these methods became routine. Another very promising method is bioimpedance of the human body. This measurement is based on the resistance and reactance caused by human body when alternating current is applied (17).

Total body bioimpedance has been proved to correlate with hydration state in hemodialysis patients. But the majority of the resistance is caused by extremities and only 9% is caused by trunk – which is the main water container in human body (20). So we can suspect that the sensitivity of this method can be insufficient when there are only little changes in hydration state. That is why Patterson and later Zhu and coworkers have studied segmental bioimpedance (12, 13, 20, 21). Zhu et al. have applied multifrequency bioimpedance, and measured separately every extremity and trunk. The result was the sum of estimated fluid. He found a strong correlation with hydration state changes, which was independent of body position, and so sensitive that this method could detect peritoneal fluid exchange in dialysis patient. But there are some reports that this method underestimates body fluid changes during hemodialysis session (1).

Thorax, one of body segments is a very dynamic region, where fluid content is moderated by cardiac uotput, body position and other factors influencing preload or afterload. In our study (Swatowski et al. ASAIO 2004 in press) we have shown that thoracic impedance (TI) correlates with hydration state changes in hemodialysis patients, and also during hemodialysis session changes parallel with ultrafiltration. To make such measurement reproductable, it must be performed in well defined and repeatable conditions. There were some additional factors influencing thoracic impedance measurements, such as the use of the acetate or bicarbonate dialysis fluid, which was reported previously (18). But there are factors that can accidentally affect bioimpedance measurement in this region.

MATERIAL AND METHODS

TI was measured during hemodialysis with the Kardio-Com device (Diefenbach Elektromedizin, Frankfurt/M) using an alternating current of 400 μA at 40 kHz. Two pairs of silver band electrodes were placed on the root of the neck and 5 cm above, and at the xiphoid level, and 5 cm beneath the xiphoid. In each presented case the patient did not change his body position during the whole measurement. The presented cases are the ones which were excluded from the study described above.

RESULTS

During our study we have recorded some events, like acute atrial fibrillation, intradialytic hypotension, food eating and receiving nitroglycerin.

The patient during hemodialysis session had an acute atrial fibrillation. The moment of onset of fibrillation caused reduction of the measured value by 1 ohm, though the ultrafiltration rate was stable. Probably the atrial fibrillation caused lowering of cardiac output and thus retention of blood in thorax. This situation could cause lower electrical resistance which influenced thoracic impedance measurement (Fig. 1). From this time point TI changed parallelly to previous measurement, but was shifted by value of about 1 ohm.

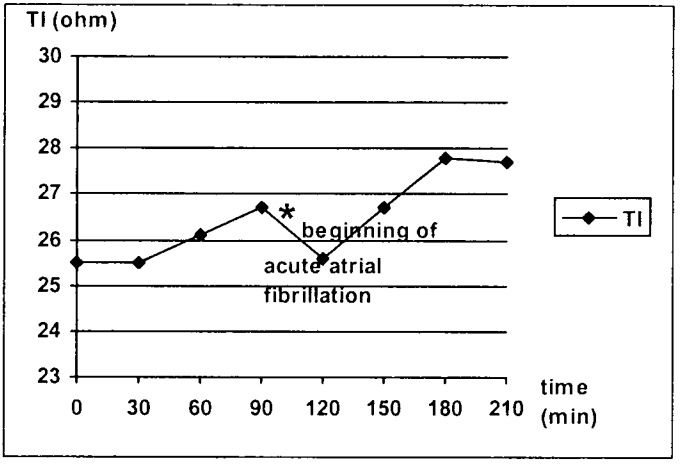

Fig. 1. The episode of an acute atrial fibrillation during hemodialysis

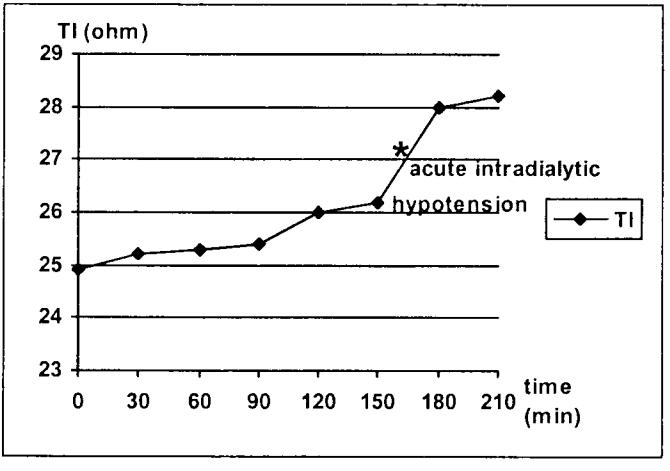

Fig. 2. Thoracic impedance changes during intradialytic hypotension

In the second case we have observed an acute intradialytic hypotension, where the TI value suddenly increased, not proportionally to ultrafiltrated fluid (Fig. 2). S h u l m a n et al. observed that during hemodialysis there is centralization of circulating blood (16). When hypotension de-

velops, it can be caused by insufficient centralization mechanisms. The possible explanation of this event is lower blood retention in thorax and this way lower preload.

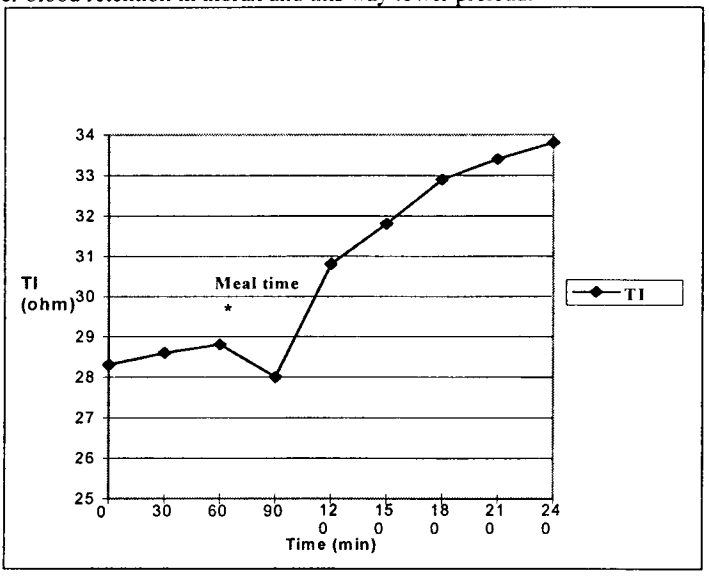

Fig. 3. Thoracic impedance changes during hemodialysis, influenced by meal

In the third situation the patient has received a meal during hemodialysis. In the first moment there was a lowering of TI value followed by a sudden increase in thoracic impedance (Fig. 3). This result was probably caused in the first phase by the presence of meal in stomach and then by fluid shift to gastrointestinal tract, which after lowering in bioimpedance caused its increase.

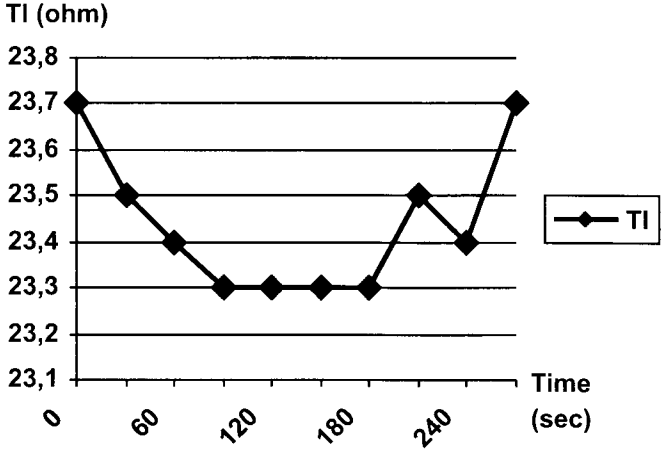

Fig. 4. The influence of sublingual nitroglycerine on TI value in the hemodialysis patient

In the fourth case we have observed the influence of received sublingually dose of nitroglycerine. After receiving this drug there was a lowering of the TI value. This result lasted for 4.5 minutes and then returned to the previous value (Fig. 4). Probably due to vasodilatation of venous vessels in thorax, the retention of blood in this region increased and thus caused lowering of impedance value.

DISCUSSION

Thoracic impedance has been shown to change parallelly with ultrafiltrated fluid during dialysis (3, 6, 7, 19). The basal value of thoracic impedance is characteristic only of an individual patient, but relative changes correlate with fluid removal, so during stable ultrafiltration are rather stable.

The presented events were excluded from the study performed on hemodialysis patients, because of not standardised factors that influenced the measurement. But after analysis of these data, the question arises, if thoracic impedance is the new way to find out something more about dialysis physiology? Hemodialysis is a very dynamic process, in which the osmosis and removal of waste products, which causes osmolality changes, is followed by ultrafiltration (15). Such combination can in some circumstances lead to intradialytic hypotension or stimulates cardiac arrythmia or disequilibrium syndrome (4, 14). Better understanding of these processes can be very helpful in proper dialysis treatment. Our study showed that unawaited changes of thoracic impedance were always connected with additional events, and thus probably could serve as early warning. Further study is required.

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SUMMARY

Hydration state is a well known problem in hemodialysis patients. There are some methods which are helpful in assessing proper target weight. Thoracic bioimpedance correlates with hydration state changes in hemodialysis patients, and also during hemodialysis session changes parallel with ultrafiltration. There are factors, that can accidentally affect bioimpedance measurement in this region, like acute atrial fibrillation, intradialytic hypotension, food eating and receiving nitroglycerin. Unawaited changes of thoracic impedance always were connected with additional event, and thus probably could serve as early warning. Further study is required.

Problemy z monitorowaniem impedancji klatki piersiowej pacjentów hemodializowanych – doświadczenia własne

Stan nawodnienia jest powszechnie znanym problemem u chorych dializowanych. Istnieją jednak metody, które są pomocne w ustaleniu wagi należnej. Bioimpedancja klatki piersiowej koreluje ze zmianami stanu nawodnienia u pacjentów hemodializowanych i zmienia się w czasie dializy równolegle do ultrafiltracji. Istnieją czynniki, które mogą wpływać na pomiar bioimpedancji tej części ciała, jak na przykład epizod migotania przedsionków, hipotonia śródzabiegowa, spożycie posiłku czy przyjęcie nitrogliceryny. Nieoczekiwane zmiany impedancji klatki piersiowej były zawsze związane z dodatkowym czynnikiem i w ten sposób mogą przypuszczalnie stanowić wczesny sygnał ostrzegawczy. Wymagane są dalsze badania.