Pneumatic compression devices to avoid intradialytic morbid events

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Tai et al. [1] have contributed a report of interest to the dialysis community in this issue of Nephrology Dialysis Transplantation. The question of how to efficiently remove excess fluid in patients on hemodialysis, particularly in those prone to intradialytic hypotension, is unfortunately always current. When associated with compromised cardiac function, usually systolic or diastolic dysfunction, or autonomic failure or even when these are not present if large fluid volumes are present, intradialytic problems are magnified. For this reason, attempts to increase the mobilization of pooled volume in the lower limbs with redistribution to the central blood volume compartment have always been a subject of interest in the dialysis community [2–4], but have also been studied in fields such as sport medicine, surgery and general physiology. In clinical medicine, the most common use of pneumatic compression is currently the removal of lymphedema where sometimes volumes need to be removed.

With continued standing, as a result of the force of gravity, venous blood and extracellular fluid pool in the lower limbs and a reduction in central blood volume may occur [5]. Analogously in the hemodialysis patient, extracellular fluid may accumulate disproportionally in the lower limbs with less elsewhere [6, 7]. Of note, in ambulatory dialysis patients, this may be the last site where excess fluid is present during intradialytic ultrafiltration [6, 7]. By resulting in an increase in intramuscular pressure, the muscle pump supports blood flow on the venous side of the cardiovascular system and has been shown to increase blood flow in the lower limbs [8]. Active contraction of large-diameter leg muscles and the powerful gluteal muscles are effective against orthostatic hypotension [8]. Similarly, tiptoeing, and to a smaller extent leg-crossing, when standing are actions that improve the functionality and effectiveness of the muscle pump in maintaining hemodynamic stability in the general population [8, 9]. Plantar stimulation by vibration has been reported to improve venous return or increase in lymphatic flow from the lower limbs resulting in increased blood volume and cardiac output in the general population and in dialysis patients [10, 11]. The use of compression acts synergistically with the muscle pump to increase venous return and improve hemodynamics in the lower limbs [12–14]. Improved effort perception and increased height of a countermovement jump before and after submaximal running occur with the use of compression garments [15]. Compression of the lower limbs during laparoscopic surgery decreases the effects of a positive pressure pneumoperitoneum in lowering venous return, stroke volume and cardiac output [16–18].

In dialysis patients unable to remove excess fluid via their kidneys, fluid overload results in deleterious consequences such as elevated blood pressure, left ventricular hypertrophy, cardiac failure and increased levels of inflammation [19]. Generally, the relation between interstitial fluid and the circulating blood volume follows Starling’s law [20–22], in which oncotic and hydrostatic pressure determines fluid balance between the intravascular and interstitial compartments. This balance is of importance also during ultrafiltration when refilling redistributes volume from the interstitium to the intravascular compartment and thus increases the central blood volume and hemodynamic stability. The maintenance of hemodynamic stability is crucial in the treatment of dialysis patients, especially when inadequate interdialytic fluid removal results in intradialytic symptoms, so that slowly increasing fluid overload occurring over time is often overlooked [19]. Among strategies proposed to maintain hemodynamic stability during ultrafiltration [23, 24] are those aimed at increasing fluid mobilization from the lower limb [2–4]. Pneumatic and other means of increasing compression (and consequentially increasing intramuscular pressure in the lower limbs) aim to increase refilling from the interstitial compartment and venous return. This has been shown in earlier studies to have positive effects on hemodynamic stability. Beninson et al. showed improved
hemodynamic stability, reflected by increased removed excess volume (3.9 L during intervention treatments versus 2.8 L during control treatment; P < 0.001) and a reduced occurrence of intradialytic hypotension, in 11 fluid-overloaded patients by the use of intermittent pneumatic compression. Occurrence of intradialytic hypotension was also reduced in seven additional minimally overloaded patients, but the ability to remove excess volume showed no significant differences between a total of 170 treatments with and without pneumatic compression [3]. Onuigbo [4] showed improved hemodynamic stability and prevention of intradialytic hypotension by the use of alternating calf compression in three studied patients. In addition, the pneumatic compression prevented muscle cramps during ultrafiltration in four patients presumably by maintaining both blood volume and perfusion in a study conducted by Ahsan et al. [2].

The current study ‘Pneumatic compression devices during hemodialysis: a randomized crossover trial’ by Tai et al. is a well planned and conducted randomized cross-over trial in 51 randomized patients who underwent two hemodialyses each with and without pneumatic compression devices [1]. Hemodynamic parameters such as cardiac output and systemic vascular resistance as measured by the transonic system, as well as systolic and diastolic blood pressure, did not improve, but a trend was apparent for a greater reduction in total body water. Of significance was the reduction in intracellular volume only with ultrafiltration which the authors suggest as evidence that their patients were not severely fluid overloaded. This may, as the authors conclude, partially be due to the use of a low dialysate sodium concentration which excludes the possibility of sodium loading during the dialysis by positive mass transfer of sodium, and its associated sequelae. The largely negative results were also present in patients prone to intradialytic hemodynamic instability, which suggests that the trend to increase the fluid volume available from pneumatic perfusion was not enough to influence the instability. Further, the present study was, as recognized by the authors, not sufficiently powered to show differences in patients prone to hemodynamic instability. In addition, as stated by the authors, a healthy volunteer bias may explain the lack of severely fluid-overloaded dialysis patients. In light of the paper, lower limb compression may not facilitate fluid management in patients with mild degrees of fluid overload. As discussed by the authors, a benefit, which was not seen in their patient cohort, might be seen in severely fluid-overloaded patients and in those prone to intradialytic hemodynamic instability. As a consequence, adequately powered studies in patient cohorts with degrees of fluid overload more characteristic of the general dialysis population and conducted over a longer period of time of intervention might prove the technique useful during ultrafiltration in the maintenance of blood volume. In regard to the existing literature showing positive effects of pneumatic compression devices, this concept is corroborated [2–4]. Sequential or progressive pneumatic compression devices might well be utilized more often than they are at present in fluid-overloaded patients, particularly those with venous valvular failure.

CONFLICT OF INTEREST STATEMENT

N.W.L. holds stock in Fresenius Medical Care NA.


REFERENCES

Placing a primary arteriovenous fistula that works—more or less known aspects, new ideas

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ABSTRACT

Despite the pre-operative availability of well-defined criteria to create a primary arteriovenous fistula (AVF) a high early failure/missing maturation is complained worldwide. Based on new results from basic research using numerical techniques, the authors try to guide attention to a widely neglected field in published data: the unremarkable, small, but essential surgical details in creating a successful AVF. The aim is to describe their significance and to give them a place in a cross-border context.

In this issue of NDT, Ene-Iordache et al. [1] present their study ‘Effect of anastomosis angle on the localization of disturbed flow in side-artery-to-end-vein fistulae for haemodialysis access’. Many nephrologists may be astonished to find such a specialized article highlighting a small detail of surgical technique.

For the authors of this editorial, experienced nephrologists and active in access surgery over a period of many years, the work of Ene-Iordache et al. represents a landmark in the field of the unremarkable, widely unknown, rarely published if ever, but absolutely determining aspects of arteriovenous fistula (AVF) creation—worthwhile to talk about. We will try to describe their significance and to give them a place in a cross-border context [2].

There is general consensus in the literature and all guidelines on the superiority of AVF over arteriovenous graft (AVG) and central venous catheter regarding patient’s survival and complications such as thrombosis, infection, access-related

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