

OPTIMIZED CONVECTIVE VOLUME IN ONLINE HEMODIAFILTRATION

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Abstract

Hemodiafiltration (HDF) adds convective elimination of middle molecules (MM), proportional to filtered volume (V_{conv}) on the top of diffusion-based elimination of small molecules (SM) by conventional hemodialysis (HD). Studies, both observational and randomized controlled ones, performed so far generally indicated positive impact of higher V_{conv} on all-cause mortality in HDF patients, although the magnitude of V_{conv} at which HDF becomes apparently superior to HD differed widely among the studies. Also the issue of a suitable anthropometric parameter by which the V_{conv} should be normalized has not yet been solved. Data from the ESHOL study seems to indicate that patient's body surface area (BSA) could well be used for this—mortality was decreasing with increasing V_{conv}/BSA with a bottom plateau starting at about 15 L/m^2 . We have therefore devised a formula and a graph for determination of V_{conv} which fulfils the requirement $V_{conv}/BSA = 15$. Assuming maximum feasible and safe filtration fraction $QF/QB = 0.3$, the V_{conv} actually defines the necessary blood flow (QB) to reach $V_{conv}/BSA = 15$ as $QB = 15 \cdot BSA / (0.3 \cdot t)$ (t – session time). It is also possible to check what QB is needed in terms of sufficient diffusion-based transport (target Kt/V) and compare both QB values to see if adequate combined elimination of both SM and MM can be achieved at the same time and under what conditions, respectively.

Keywords

treatment adequacy, prescription, monitoring, hemodiafiltration, convective volume, body surface area, filtration fraction, blood flow, hemodialysis, combined approach

Introduction

Hemodiafiltration (HDF) adds convective elimination of middle molecules (MM) on the top of diffusion-based elimination of small molecules (SM) by conventional hemodialysis (HD). However, unlike the situation in SM range, where the “relative dialysis dose” Kt/V is generally accepted as its adequacy marker with its target value defined by randomized controlled studies [1, 2] and included in existing guidelines [3, 4] there is only a general consensus that the “absolute dialysis dose” in MM range may be represented by the convective volume (V_{conv}). No consensus exists as to which anthropometric parameter should be used to convert that absolute dose into a relative one which would enable to compare HDF efficacy in different individuals. Consequently, also no target value for the

absolute V_{conv} and its relative value exists either. The result is widely varying prescription of HDF effectively hindering reliable comparison of its outcome reported by different groups. From among the plethora of studies on online HDF, only one study [5] provided some data for the search of a suitable anthropometric parameter applicable for V_{conv} normalization needed to find its upper target value above which no further benefit for the patient could be expected. Indeed, V_{conv} normalized by BSA indicates that mortality of patients on HDF may be reaching its bottom plateau for values of V_{conv}/BSA around 15 L/m^2 .

Based on this estimation, this article devises computational and graphic approach for prescription of desirable V_{conv} according to patient height and weight (parameters used to estimate his/her BSA). Assuming further reasonable and safe value of filtration fraction $FF = QF/QB = 0.3$ (QF – filtration rate, QB – blood

flow during HDF), necessary QB is defined to reach the target value of “convective dose”. Finally, the QB defined in this way is compared to the QB needed to reach target value of the conventional “diffusive dose” Kt/V constituting thus truly combined approach to HDF adequacy in both SM and MM range.

Prescription and efficacy assessment of the convective elimination in HDF

Hemodiafiltration (HDF) was developed as a more advanced hemoelimination method to fully utilize potential of the highly permeable (high-flux) membranes introduced in the seventies and eighties to remove MM uremic toxins by convection, additionally to diffusion-based elimination of SM catabolites by conventional hemodialysis (HD). The well-known HDF principle is shown in Fig. 1.

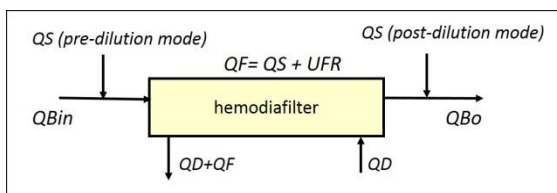


Fig. 1: Principal scheme of pre- and post-dilution mode HDF.

Convective removal rate (m) is given by the product of filtration rate (QF) and concentration of the given solute in plasma water (CP) in the blood path of the hemodiafilter. The sieving coefficient SC ($SC = CF/CP$) reflects possible differences between CP and concentration in filtrate (CF).

$$m = QF \cdot CP = QF \cdot CF \cdot SC \quad (1)$$

Filtration rate (QF) exceeds significantly patient's ultrafiltration needs (UFR) and that part exceeding UFR is replaced by a continuous inflow of substitution fluid (QS) in the blood path so that the overall volume balance is preserved:

$$QF = QS + UFR \quad (2)$$

Addition of substitution fluid at the hemodiafilter blood inflow or outflow defines pre-dilution or post-dilution HDF mode.

As in any other hemoelimination procedure, efficiency of a solute removal in HDF is characterized by the term clearance (K). Physically, K of a certain solute is that fraction of blood flow from which that solute is completely removed during blood passage through the cleansing device, regardless of the physical principle by which the transport of the solute in the device is

accomplished. Assuming for simplicity that an MM solute is removed in HDF only by convection (diffusion is neglected) and that its $SC = 1$, K in the post-dilutional HDF will be equal to filtration rate QF

$$K = QF \quad (3)$$

and the cleansed volume (V_{conv}) will constitute **absolute convective dose** of the HDF procedure.

$$V_{conv} = QF \cdot t \quad (4)$$

As a matter of fact, convection occurs in HDF simultaneously with diffusion and both phenomena thus interfere with each other. Due to diffusion, concentration in blood decreases along the hemodiafilter (mainly in SM region) and reduces thus the convective removal, i.e. the amount of solute transported across the membrane with filtrate. Convection realized by the filtrate flow QF reduces on the other side blood flow and thus diminishes diffusional transport determined mainly by flows. Impact of this interaction on elimination of solutes of different molecular weight is well demonstrated in Fig. 2 adapted from [6]:

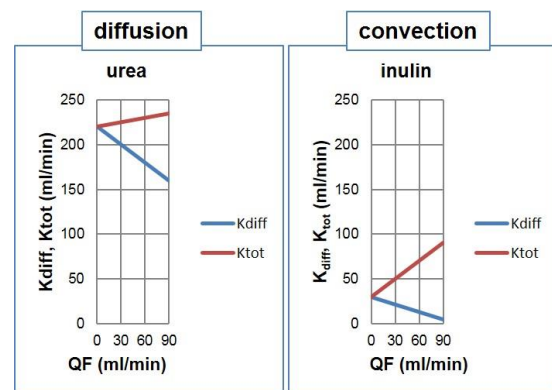


Fig. 2: Interaction between diffusion and convection in postdilutional HDF (adapted from [6]).

In case of urea (mol. weight 60), diffusion decreases significantly with increasing QF and overall contribution of convection to total clearance K_{tot} is just marginal. For inulin (mol. weight around 5000), on the contrary, reduction of diffusion with increasing QF is just small but increase of K_{tot} is highly significant. Removal quantification of solutes with even higher molecular weight (e.g. β_2 microglobulin, myoglobin etc.) by means of “convective dose” V_{conv} is thus well justified.

With definition of the “convective dose” inevitably comes the question of how high it should be. Based on several observational studies which reported decreasing mortality with increasing V_{conv} , part of the nephrological community adopted the approach “the higher the better”. Fresenius company as the leader in introducing on-line HDF in clinical practice gave the “hall-mark” to this approach by their concept of “high-

volume HDF". It was based on three randomized controlled trials—the Dutch CONTRAST study [7], the Turkish study [8], and the Catalonian ESHOL study [5]. All three tried to find out whether the on-line HDF is better than conventional HD primarily in all-cause mortality and if so at what V_{conv} this would become apparent. The CONTRAST study compared HDF with low-flux HD and better all-cause mortality was found only in a *post hoc* analysis after separation the HDF group in terciles in the highest tercile ($V_{conv} > 21.95$ L). In the Turkish study (high-flux HD vs. HDF), again in a *post hoc* analysis only, much lower volume was found ($V_{conv} > 17.4$ L). In the Catalonian study, *post-hoc* analysis showed marked improvement in all-cause mortality with the highest volumes ($V_{conv} > 25.4$ L). Those rather inconsistent results allowed only two general conclusions: The on-line HDF is definitely not inferior to conventional HD and all-cause mortality in HDF patients generally decreases with increasing V_{conv} . None of the three studies provided an upper target value of V_{conv} above which no further improvement in mortality could be expected and none tried to systematically look for an anthropometric parameter which could be used to define a target relative convective dose of HDF. Nevertheless, the Catalonian study provided at least some data for such a search (supplemental Tab. 4 in [5]). Fig. 3 shows three plots we have created from that Tab. 4:

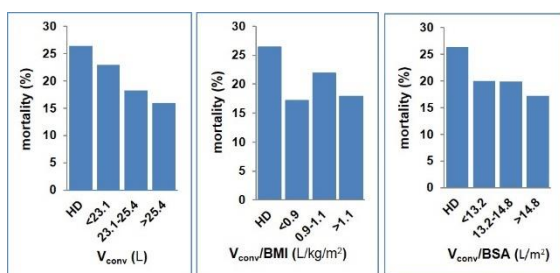


Fig. 3: All-cause mortality in HDF vs. V_{conv} , V_{conv}/BMI and V_{conv}/BSA , for comparison also mortality seen in HD, adapted from [5].

The left plot shows ever decreasing mortality with increasing absolute V_{conv} . The absolute value thus cannot define the upper limit of V_{conv} over which no further benefit could be expected (which would mimic adoption of target $spKt/V = 1.4$ after evaluation of the HEMO study [2]). Middle plot displays mortality vs. V_{conv} normalized to body mass index (BMI). With increasing V_{conv}/BMI , mortality fluctuates, i.e. BMI does not appear a good normalizing parameter either. It is only the right plot of mortality vs. V_{conv}/BSA which shows flat running pattern—ceasing of mortality decrease for V_{conv}/BSA over 14–15 L/m², suggesting that body surface area (BSA) could well be the sought normalizing parameter. It seems perfectly logical because it is known that metabolic turnover responsible for production of catabolites (to be removed by hemolimitation techniques in renal failure) is proportional

to BSA [9]. Also glomerular filtration rate (GFR) used to assess excretorial kidney function has traditionally been normalized to BSA , not to total body water V . Those were the reasons which lead us to use V_{conv}/BSA as a marker defining "relative convective dose" in HDF.

Based on the data from the ESHOL study, the target value of V_{conv}/BSA over which it would have no sense to go because it does not improve mortality any further is estimated as

$$V_{conv}/BSA = 15 \text{ or } V_{conv} = 15 \cdot BSA. \quad (5)$$

The most often used formula for BSA estimation is that published by Dubois [10]

$$BSA = 0.20247 \cdot H^{0.725} \cdot BW^{0.425} \quad (6)$$

where H means patient's height in meters and BW his/her body weight (post dialysis) in kg.

Combining Eq. (5) and (6) it is possible to express also the target V_{conv} , needed to fulfil Eq. (5), in terms of H and BW , and convert it into a graphic form—see Fig. 4. The plot can be used for an easy prescription of the target V_{conv} .

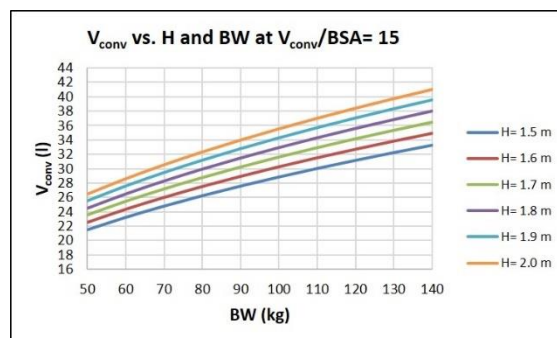


Fig. 4: Plot for V_{conv} prescription from H and BW fulfilling the requirement $V_{conv}/BSA = 15$.

After defining the target V_{conv} , a question arises how to reach it. Once the V_{conv} target value is either calculated from Eq. (5) or read from the plot in Fig. 4, it determines filtration rate $QF = V_{conv}/t$ where t is the session time (from organisational reasons, the same t value is quite often used in the renal unit for all patients). And QF , in turn, defines the blood flow (QB) needed to reach that QF safely, i.e. without excessive risk of blood clotting in the dialyzer because of too high hemoconcentration. The EUDIAL working group (established within the EDTA/ERA to enhance quality of hemoelimination therapies in general) addressed the issue of optimal running parameters of online HDF and suggested in their report [11] that because of the clotting risk, the filtration fraction (FF) ($FF = QF/QB$) should be limited to 20–25%. This is in correspondence with measurement of the fibre bundle volume (FBV) changes during post-dilution HDF [12] done in our unit some time ago—see Fig. 5.

FBV is the volume of the dialyzer blood path and procedure for its evaluation by means of ultrasonic dilution was described in [13]. The $\Delta FBV(\%)$ denotes its relative change during an HDF session. The plot shows the mean ΔFBV values obtained from a group of 8 patients hemodiafiltered at identical HDF setting except for the *QF* value. As can be seen from the plot, while the change in *FBV* was negligible with $FF = 0.2$ (only 1.07%), it increased to over 10% with $FF = 0.3$, indicating loss of functional fibres by deposits and clotting. As far as I know, no such measurement has been made with advanced algorithms for automatic control of *QF* aimed at maximization of V_{conv} (Autosub^{Plus} of Fresenius or Ultra^{Control} of Gambro) which usually work at higher FF —up to 0.35, rather surprisingly without any apparent problems with increased clotting.

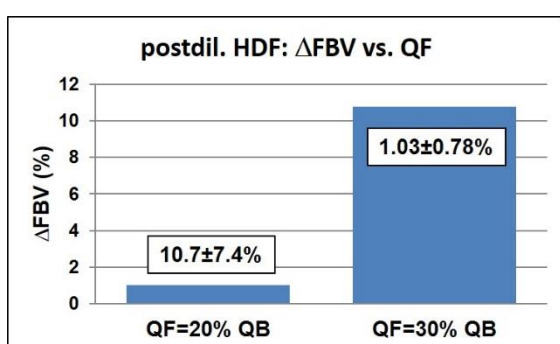


Fig. 5: Reduction in fibre bundle volume during online HDF at $FF = 20\%$ and 30% (data from the Prague – Strahov dialysis unit, *FBV* measured with the HD01 device, Transonic Systems).

Considering all the above, value of $FF = 0.3$ appears as a reasonable compromise, especially when machines without automatic V_{conv} control are used. For this FF , the formula for *QB* allowing to reach prescribed V_{conv} (as defined by Eq. (5) or the plot in Fig. 4) can be written:

$$QB = QF/FF = 3.3 \cdot QF = 3.3 \cdot V_{conv}/t \quad (7)$$

Combining Eq. (7) with Eq. (4), (5) and (6), it is possible to express *QB* in terms of patient's *H* and *BW* graphically:

$$\begin{aligned} QB &= 3.3 \cdot 1000 \cdot V_{conv}(L) / t(\text{min}) \\ &= (3300 \cdot 15/240) \cdot 0.20247 \cdot H^{0.725} \\ &\quad \cdot BW^{0.425} \end{aligned} \quad (8)$$

(*H* in m; *BW* in kg, and $t = 240$ min).

In principle, the graph in Fig. 6 is merely a recalculation of Fig. 4. It is, nevertheless, helpful to have both, because in HDF machines without automatic *QF*

control, it is necessary to set desired value of V_{conv} and *QB* separately. In machines with automatic *QF* control, only *QB* has to be set, maximized V_{conv} is obtained automatically, although its value reached at the end of the session is not known in advance.

*Note: Prescription of the QB value and the V_{conv} to fulfil the requirement $V_{conv}/BSA = 15$ is valid for post-dilution HDF only. For pre-dilution HDF, both *QF* in Eq. (5) and V_{conv} read from Fig. 4 must be increased proportionally to the dilution factor $DF = (QB+QS)/QB$.*

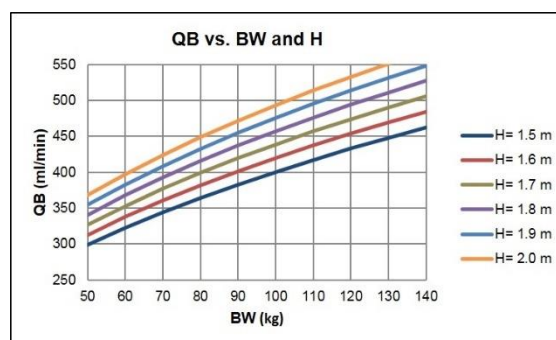


Fig. 6: Plot for prescription of *QB* needed to reach $V_{conv}/BSA = 15$ at $FF = 0.3$ (calculated for HDF session time $t = 4$ hours).

The *QB* value defined by the Eq. (8) or Fig. 6 is based on requirements posed on the efficacy of convective elimination of MM catabolites (sufficient V_{conv}/BSA). However, *QB* is also responsible for sufficient diffusive elimination in the SM region (adequate Kt/V). If we define the “diffusion-needed” *QB* in terms of the same anthropometric parameters as the *QB* resulting from consideration of convective transport efficacy, we can see whether it is possible to find a *QB* able to ensure sufficient efficacy both in diffusive SM elimination as well as in convective elimination of MM.

Necessary *QB* for adequate diffusive elimination in SM region

Theoretical background of requirement on *QB* for HD dose prescription and monitoring (Kt/V) has been developed earlier [14]. It is based on two simple assumptions: dialyzer urea clearance (*K*) is equal to 70% of blood flow through the dialyzer (*QB*) and total body water (*V*) is equal to 60% of body weight (post-HD weight). Combining those two assumptions ($K = 0.7 \cdot QB$ and $V = 0.6 \cdot BW$) with the target Kt/V value $Kt/V = 1.2$ leads to surprisingly simple pre-scription of *QB* and monitoring of HD adequacy:

$$Kt/V = 0.7 \cdot QB \cdot t/0.6 \cdot BW = 1.2 \quad (9)$$

Rearranging Eq. (9) gives the formula for prescribing individualized QB based on patient's BW :

$$QB = Kt/V \cdot 0.6 \cdot BW / (0.7 \cdot t) \quad (10)$$

$$= 1.03 \cdot BW / t$$

Eq. (10) can be displayed in a graphic form of QB vs. BW with session time t as a parameter. Resulting plot is shown on Fig. 7.

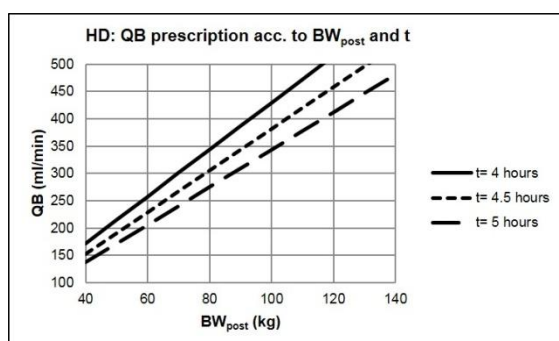


Fig. 7: Prescribed QB vs. BW and t ($Kt/V = 1.2$; $K = 0.7QB$; $V = 0.6BW$) according to Eq. (10).

The plot was calculated for $Kt/V = 1.2$ but can be easily modified using Eq. (9) and (10) if a Kt/V different from 1.2 should be obtained.

Rearrangement of Eq. (9) then provides a simple and elegant approach to estimation of the delivered Kt/V at the end of HD: In Eq. (9), $QB \cdot t$ actually gives the value of total blood volume processed during HD (VB), a parameter displayed today by practically all dialysis machines. A formula to estimate delivered Kt/V in terms of VB/BW can thus be devised:

$$Kt/V = 0.7 \cdot VB / (0.6 \cdot BW) \quad (11)$$

$$= 1.17 \cdot VB / BW$$

Eq. (11) actually says that Kt/V of 1.2 is delivered if the processed blood volume roughly equals body weight. Very simple rule without any need for blood sampling! Practical verification of QB prescription according to BW and delivered Kt/V estimation from the VB/BW value has been done in a larger patient cohort and resulted in sensitivity and specificity of inadequate Kt/V detection ($Kt/V < 1.2$) 75% and 85%, respectively [15, 16]—see Fig. 8.

Minor discrepancies from good correspondence between conventionally measured Kt/V and VB/BW (the right bottom quadrant and the left upper quadrant) were seen in patients with higher BMI (the left upper quadrant of the plot, i.e. with $V < 0.6 \cdot BW$) or in malnourished patients with low BMI (the right bottom quadrant, i.e. $V > 0.6 \cdot BW$).

Note: The target value $Kt/V = 1.2$ in the above calculations was used because the in vivo data was obtained on dialysis machines with the online Kt/V

evaluation which gives Kt/V values closer to equilibrated Kt/V (eKt/V) rather than to single-pool Kt/V ($spKt/V$) [3, 4].

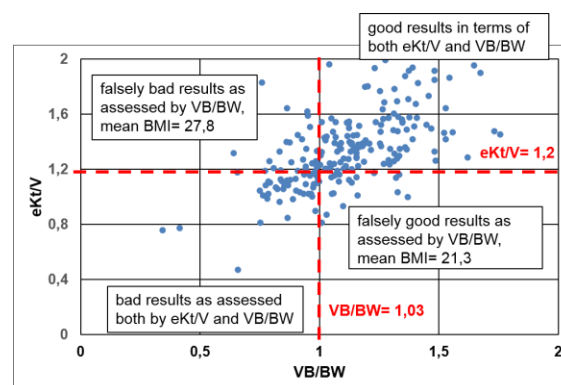


Fig. 8: In vivo eKt/V vs. VB/BW relation—influence of anthropometric factors [16] (data from the Prague – Strahov dialysis unit).

Combined prescription and efficacy assessment in HDF

As has been shown in the above two paragraphs, the prescribed QB affects treatment efficacy both in the SM (diffusion-based transport) and MM region (convective transport), although in both cases via different mechanisms. QB thus has a “double function”. With defined QB value needed to achieve adequate dialysis in SM region characterized by the Kt/V value and QB needed to reach sufficient V_{conv}/BSA as the adequacy marker in MM region, it is possible to look whether a common QB can be found which would fulfil both requirements, i.e. $Kt/V = 1.2$ and $V_{conv}/BSA = 15$ in a particular patient.

According to Eq. (10), the QB value needed to reach the target Kt/V value at a given t depends primarily on patient's body weight. Assuming a technically feasible filtration fraction $FF = QF/QB = 0.3$, it is possible to calculate obtainable value of V_{conv} at a given QB combining Eq. (7) and Eq. (11):

$$V_{conv} = QF \cdot t = 0.3 \cdot QB \cdot t \quad (12)$$

$$= 0.3 \cdot 1.03 \cdot BW = 0.309 \cdot BW$$

This formula represents a straight line in a plot of V_{conv} vs. BW such as the plot in Fig. 4. Adding the line corresponding to Eq. (12) in the plot at Fig. 4 (read dashed line), a modified plot is obtained (Fig. 9), enabling combined approach to V_{conv} prescription to fulfil the target values of both diffusion-based adequacy marker Kt/V and the novel convection-based adequacy marker V_{conv}/BSA .

Due to the higher slope of the red dashed line obtained from Eq. (12) for increasing BW , it intersects the

lines V_{conv} vs. BW calculated by Eq. (8). In the red area left from the intersection region (BW below cca 85 kg), QB prescription needed to reach target Kt/V would not be able to reach $V_{conv}/BSA = 15$ and QB must be prescribed according to Eq. (8) giving priority to the “convective dialysis dose”. In the middle green region, prescription of the QB both according to Eq. (12) and Eq. (8) would roughly enable to reach both the target Kt/V and the V_{conv}/BSA . On the contrary, in the largest body size patients (for BW over cca 125 kg), the target “convective dose” would be reached but the “diffusive dose” would not, i.e. in that region, QB should be prescribed according to Eq. (12). This discordance in QB prescription would partly be solved by the novel requirement for a non-uniform Kt/V value which would account for gender and body size—see the *Discussion* paragraph below.

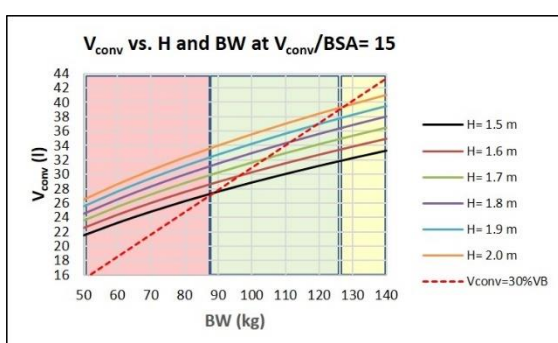


Fig. 9: Combined approach to prescription of adequate HDF.

Discussion

The above described novel combined procedure is at present merely a hypothesis how the issue of HDF prescription and adequacy assessment could be practically done. Suitability of the V_{conv}/BSA as a convective adequacy marker, whatever intuitively logical, is at present supported only by limited amount of clinical data taken from the ESHOL study. Thus, larger statistically sufficiently powered studies will be needed to confirm the suggested approach.

The problem of discordance between the QB needed to reach both adequate Kt/V ($= 1.4$ or 1.2 , respectively) and adequate V_{conv}/BSA ($= 15$) is a consequence of different normalizing parameter in both cases— V in the former and BSA in the latter. As a matter of fact, after about two decades of enthusiastic use of Kt/V when a lot of observational studies documented close association of Kt/V with all-cause mortality, some discrepancies appeared which pointed towards problems with its universal target value for all patients. Owen [17] detected in his study gender dependence of an adequate relative dialysis dose (for the same survival, the Kt/V needed in females was higher than that in males). Wolfe [18] found the same for small and large body

size patients – smaller patients needed higher Kt/V than the larger ones. While the two above mentioned studies were just observational, their conclusions were subsequently confirmed by the large randomized controlled HEMO study [19, 20]—female and small patients indeed needed higher Kt/V than males and patients with a larger body size. Several researchers tried to solve the problem of adjusting the Kt/V to patient’s gender and/or body characteristics by using a different parameter for Kt normalisation. The so far most elaborated approach has been offered by Daugirdas [21] using the ratio of total body water V and body surface area BSA to define a modified Kt/V ($modKt/V$):

$$modKt/V = (conventional Kt/V) \cdot (V/BSA)_{ref} / (V/BSA)_{pat} \quad (13)$$

He analyzed the huge patient data pool from the HEMO study and suggested a gender and body size-dependent equation of the ratio V/BSA . As the reference value of the V/BSA ratio ($(V/BSA)_{ref}$), he used the mean value from the whole patient cohort in the HEMO study (over 1700 patients) – 20 L/m^2 .

Fig. 10 shows the $mod Kt/V$ vs. BW using Eq. (13) separately for males and females of different BW and H , calculating BSA according to Dubois Eq. (6) and total body water V (in liters) according to Watson’s formulas [22] assuming conventional $spKt/V = 1.4$ (dashed red line, Fig. 10).

For males:

$$V = 2.447 - 0.09156 \cdot A + 0.1074 \cdot H + 0.3362 \cdot BW \quad (14)$$

For females:

$$V = 0.1069 \cdot H + 0.2446 \cdot BW - 2.097 \quad (15)$$

with A being patient’s age (years), H his/her height (cm) and BW his/her body weight (kg).

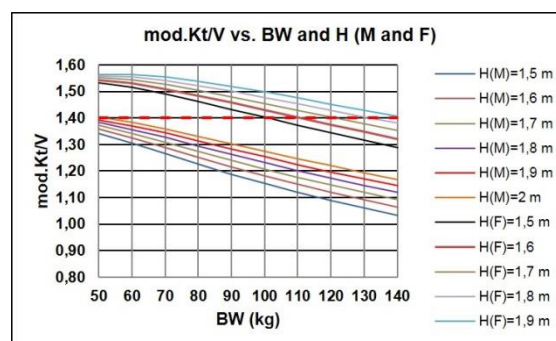


Fig. 10: $ModKt/V$ calculated by Eq. (13) vs. BW calculated for conventional $spKt/V = 1.4$ and $(V/BSA)_{ref} = 15$.

The dashed red line in the plot represents the current uniform $spKt/V$ value 1.4 . The upper set of curves represents females with height $H(F)$ from 1.5 to 1.9 m.

Only females with large body size need lower Kt/V than the currently used target ($spKt/V = 1.4$, $eKt/V = 1.2$), smaller females, on the contrary, need higher Kt/V . As for males (the bottom set of curves with height $H(M)$ from 1.5 to 2.0 m), target $modKt/V$ has the same value as is the current target, while the largest body size males would need significantly less. The $modKt/V$ thus accounts for both previously published objections against a uniform Kt/V for all patients. And in fact, this modified approach to “diffusive dose” Kt/V would also partly solve the discordance between the QB needed to reach sufficient diffusional $modKt/V$ and QB calculated from the desirable V_{conv} . The slope of the Kt/V -derived line (red dashed line in Fig. 9) would become less steep and would thus get closer to curves generated from the condition $V_{conv}/BSA = 15$. It means that application of the modified Kt/V approach would lead to better correspondence in QB needed for sufficient diffusional and for convective elimination efficacy of HDF.

Summary and conclusions

In online HDF, treatment dose in SM (diffusion-based dose) and MM range (convective dose) are defined separately. Surrogate of the relative diffusion-based dose has traditionally been Kt/V with a uniform target value. Absolute convective dose of post-dilutional HDF is well defined by the convective volume V_{conv} , although there is no generally accepted target value of it. There is also no consensus on an anthropometric parameter for conversion of absolute “convective dose” to a relative one and hence also no accepted target value of it either. Based on generally assumed direct proportionality between metabolic turnover and limited amount of data from the ESHOL study, this article suggests introduce V_{conv}/BSA as the relative convective dose with a target value of 15 L/m².

For practical application of the above suggestion, use of the plots in Fig. 4 and Fig. 6 is sufficient. First, the V_{conv} value read from the plot at Fig. 4 for the BSA (H and BW) of a given patient is prescribed and subsequently necessary QB value to reach that V_{conv} is read from Fig. 6 and set on the HDF machine. In machines with automatic control of QF via the filtration fraction FF , only the QB needs to be defined prior to HDF start and the FF value set to 0.3. Even in HDF machines equipped with automated maximisation of V_{conv} , which do not need V_{conv} prescription, the suggested concept of V_{conv}/BSA can still be used to assess adequacy of V_{conv} reached.

There is certain dissonance between the QB needed to reach adequate Kt/V ($spKt/V = 1.4$ or $eKt/V = 1.2$ in thrice weekly schedule) and QB needed to reach adequate value of the newly suggested marker of “convective dose” V_{conv}/BSA —see Fig. 9. The QB value derived from the target value of the conventional Kt/V is lower than the V_{conv} -derived QB in patients with BW

up to cca 85 kg. Hence the QB prescribed for an adequate HDF in smaller patients should be V_{conv} -derived. In the largest body size patients (BW over 125 kg), the opposite is true.

The above-mentioned dissonance in QB prescription based on “diffusive dose” (Kt/V) and on “convective dose” (V_{conv}/BSA) in HDF would be less pronounced with the $modKt/V$ concept than with the conventional uniform Kt/V approach. The newly suggested concept of the relative convective dose V_{conv}/BSA is at present not supported by sufficient clinical data and larger randomized controlled studies investigating its association with mortality and other “softer” treatment outcomes (hospitalisation rate, ESA needs etc.) are thus warranted. To facilitate use of the V_{conv}/BSA and associated QB approach, an Excel file is attached to the electronic version of this article to perform all necessary calculations.

The absolute convective volume *per se* can, of course, be very well used for studies on elimination of any specific MM uremic toxin once its sieving coefficient is known.

Declaration of conflicting interests

There is no conflict of interest to declare.

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