An App Predicting Peritoneal Dialysis Appropriate Dwell Volume for Patients in Daily Quality-of-Care Practice

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Research

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Abstract

Background Few studies mention how to objectively adjust peritoneal dialysis (PD) dwell volume (DV) for adult continuous ambulatory peritoneal dialysis patients. It requires a great deal of physicians' precious time to determine the appropriate DV during daily practice. An app with evidence is required to solve this problem independently and efficiently This study aims to determine a method for fluid control that can reduce fluid overload-related complications. We proposed a reference equation composed of parameters from the peritoneal equilibration test (PET) for adjusting daily dialysate DV to obtain more ultrafiltration volume.

Methods Ninety PD patients being treated at one medical center were enrolled, with laboratory data collected during half-yearly PET evaluations. The instilled dialysate was composed of 2.57% glucose PD fluid, either 1500 ml or 2000 ml for two groups in DV. We measured intraperitoneal pressure (IPP) before dialysate instilled (P0) and drained in the supine position after four hours (P4), effluent volume (ml), body mass index (BMI), waist circumference, and other parameters, including social demographics, to predict the appropriate DV. Exploratory factor analysis (EFA) was performed to extract independent domains. Statistical multivariate techniques of discrimination analysis and logistic regression (LR) to verify the most feasible and optimal formula were applied to determine inflow volumes for patients. A final equation for fine-tuning daily DV was proposed with an app to be used for physicians and patients in clinical settings.

Results Two domains were observed by using EFA: (1) P0, and P4, and effluent volume and (2) BMI and waist circumference. We determined a formula for calculating daily dialysate DV, derived from Logistic analysis to obtain an accurate prediction rate of 94.44% with $Z = 4.32974 + 3.85477 * F1 + 3.83008 * F2$, higher than the previous study at 80.68%. An app was created to easily adjust the DV in the daily procedure.

Conclusion The novel formula, combined with an app using objective, real-time parameters for predicting appropriate DVs, was proposed for PD patients to optimize maximal ultrafiltration volumes and reduce subjective abdominal discomfort. DV is easy to calculate using the app, which makes it possible for physicians or patients to make frequent adjustments.

Highlights:

- To determine a method for fluid control that can reduce fluid overload-related complications is of importance in clinical practice.
- A reference equation composed of parameters from the peritoneal equilibration test (PET) for adjusting daily dialysate DV to obtain more ultrafiltration volume was proposed in this study.
- An app was developed to be used for physicians and patients in clinical settings in the future,

1. Introduction

1.1 Importance of the topic

Over 106,082 articles were extracted when searching the keywords “renal disease and end-stage renal disease (ESRD)” in PubMed Central on May 24, 2019. Both the incidence and prevalence of ESRD patients are highest in Taiwan around the world, with an incidence of ESRD at 418 per million people and the prevalent rate at 2,226 per million people, according to the U.S. Renal Data System 2018 Annual Data Report [1]. The percentage of patients with ESRD on continuous ambulatory peritoneal dialysis (CAPD) is relatively lower, around 7.6% [1]. Many factors cause patients to drop out of peritoneal dialyzes (PD) treatment, such as feelings of abdominal fullness and decreased appetite resulting from large dialysate volumes, inadequate fluid removal with resulting hypertension, congestive heart failure, and increased mortality [2].

A previous study addressed no apparent survival superiority with further increasing small molecular weight uremic toxin clearances [3]. On the contrary, inadequate ultrafiltration (UF) volume and higher peritoneal transport are associated with increased mortality [2]. Another article developed a formula according to patient characteristics, peritoneal equilibration test (PET) data, and intraperitoneal pressure (IPP) for predicting appropriate dwell volume (DV) to achieve maximal UF volume [4]. However, the proposed formula using a rotating X-axis method to obtain an accurate prediction rate was lower at 80.68%, below our expectation of at or around 90%.

The reason for the lower accurate prediction rate might be attributable to the methodology misused in the previous studies, such as collinear variables (i.e., body mass index [BMI] and waist circumference[WC]) combined to predict types of the PD DV for patients. In addition, insignificant variables such as ΔIPP (i.e., the difference between the intraperitoneal pressures measured in the supine position before instilled dialysate volume [P0] and drained after four hours [P4]) and ΔH4-H2 (i.e., the difference between dialysate/plasma creatinine ratio at the second and fourth hours) were abused in the models for evaluations due to their insignificance between groups.

1.2 Traditional method used to determine the PD DV

Traditionally, DV was determined by the physician taking both subjective abdominal discomfort of patients and objective BMI, WC, and differences between the two measured ratios (i.e., ΔH4-H2 mentioned above) into consideration [4]. In the literature, using measurements of intraperitoneal pressure(IPP) for adjustment of individual DV is suggested in pediatric PD patients to obtain maximal volume tolerances and UF volumes [5, 6]. Theoretically, increasing DV recruits more peritoneal membrane surface area for better uremic toxin clearance and larger UF volume. Many studies have revealed a negative linear correlation between mean IPP and UF volume [7,9]. Other studies addressed that patients are well tolerated by adult and pediatric PD patients with subjective discomfort judgment when the IPP levels are maintained at less than 18 cm H_2O and reaching optimal UF volumes [7,10]. Applying IPP measurement as part of adjusting DV can thus be decided along with the subjective tolerance levels of adult patients and the objective observation by a physician in clinical settings.

1.3 Objectives of this study

We observed two phenomena: (1) the adult CAPD patients were concerned with maximizing UF volume during PET evaluations; (2) the WC, BMI, and tolerability of patients are commonly considered by the PD physician to determine the DV for an individual patient [4]. A smaller difference between dialysate/plasma creatinine ratio measured at the second and the fourth hour of PET, as well as a smaller reduction in IPP, are required to reduce the outflow volume for CAPD treatment and make patients more comfortable. This is the motivation to develop an app to determine the appropriate DV for a CAPD patient. A formula for both physicians and patients to determine and adjust appropriate inflow volumes objectively and effectively to attain the maximum UF volumes will be examined in this paper.

2. Methods

2.1 Data and subjects

Data were obtained from the corresponding author in the previously published article [4]. In total, 90 subjects were recruited (68 women, 22 men between the ages of 18–78 years; duration of dialysis 3.7–121.5 months). Of these, 20 patients used inflow volumes of 1500 ml (group 1), and 70 patients used volumes of 2000 ml (group 2) during PET evaluations. All patients were treated with CAPD for at least three months at a medical center in southern Taiwan. None of them had a major operation, peritonitis, or acute illness within one month before enrollment in the previous study. All data were deposited in Additional File 1.

Ethical approval was not necessary for this study because all the data came from the raw data in an article published with the approval of the Ethics Review Board.

2.2 Study variables

The IPP was measured [6,11] during routine biannual PET evaluations. The dwell dialysate was 2.57% glucose solution and DVs were either 2000 ml or 1500 ml, which was the same as in the patients' daily exchange regimen. The IPP data were collected from patient visits to the hospital at the beginning and end of the PET evaluations.

The PET protocol was performed in line with Twardowski's recommendations [12].

The intraperitoneal pressure was measured in the supine position [6,13], before installation of a defined dialysate volume (P0) and before the dialysate drained out four hours later (P4). DV was determined by the physician, taking both the patients' subjective abdominal discomfort and objective BMI into consideration.

Gender, age, height, weight, BMI, CAPD duration, DVs, maximum UF volume, P0, and P4 for IPP, effluent volume, and waist circumference were recorded. The differences between the two contrast groups were examined for statistical significance using Chi-square and independent t-test for data on counts and continuous variables, respectively. The main variables that significantly affected UF were then included to develop a formula to determine the appropriate inflow volumes for PD patients.

2.3 Formulas and discriminating groups

2.3.1 Creating a New Axis

Traditionally, a one-dimensional variable was examined by using independent Student's t-test for two groups. A preferred method for performing a multivariate test is one in which both variables are tested simultaneously or jointly in a model [4,14]. This new axis, Z, in the multivariate approach, makes an angle with a variable axis, on which the projection of any point, say patient (n), on Z will be given by Z = cos(theta) * variable A + sin(theta) * variable B, where theta denotes the angle deviated from the X-axis.

This Z variable represents a linear combination of two variables (e.g., WC and BMI [4].) for patient n. The Z-axis is a linear combination of the original two variables. The ratio of the between-group to the within-group sums of squares for each angle indicates the appropriate angle on the new axis that provides the maximum separation between the two groups. The cutoff value can be determined by the binary variable (e.g., two types of groups in a study [4]) and the discriminant score (i.e., the Z variable) for groups by using the receiver operating characteristic curve(ROC) and the area under the curve (AUC) [15].

2.3.2 Group Discriminant Analysis

Discriminant analysis is a technique for separating groups, particularly more than two groups, using specific discrimination functions. The first step is to identify a set of variables (called discrimination function) that best discriminates between groups. The next is to identify a new axis to provide the maximum separation or discrimination between groups. The last step is to group the observed subjects into one of the groups to suggest an appropriate dialysate inflow volume adjustment, such that the inflow volume for an individual CAPD patient is either 1500 ml or 2000 ml.

The discriminant function denoting Z1 and Z2 was constructed, assigning observations to a specific group by the largest classification score. In general, there are two discrimination equations for two groups that are used to examine which subject is appropriate in which group. The higher value in one equation determines the group existed. For instance, the higher in equation Z1 will assign the subject to group 1, otherwise to group 2 if the higher result in equation 2.

2.3.3 Logistic Regression

Usually, when determining the probability that a CAPD patient should be assigned to either the inflow volume group (1500 ml or 2000 ml), the discriminant analysis should be based on the multivariate normality assumption. Fortunately, the independent variables are a mixture of categorical and continuous variables, in which the logistic regression (LG) can be applied without assuming the normality of the distributions of the independent variables [14]. That is, logistical regression is normally recommended when the independent variables do not satisfy the multivariate normality assumption [14].

2.4 Statistical analysis

Exploratory factor analysis (EFA) was performed for extracting independent domains. Statistical multivariate techniques of discrimination analysis and logistic regression to verify the most feasible and optimal formula were applied to determine patients' inflow volumes. A final equation for fine-tuning daily DV was proposed to create an app for physicians and patients in clinical settings. **Factor scores for each domain in data are required to predict using the multiply regression analysis due to the person factor scores are unknown when answering the app on smartphones.**

A visual representation displaying the classification effect is plotted using two curves (ie, one from the left-bottom to the right-top corner denotes the success [2000 ml] feature and another from the left-top corner to the right-bottom side as the failure attribute). The study flowchart is shown in Figure 1.

Statistical analyses were performed using MedCalc for Windows, version 9.5.0.0 (MedCalc Software, Mariakerke, Belgium), and using SPSS for Windows (Version 15) (SPSS Inc., Chicago, Illinois, USA).

===Figure 1 inserted here===

3. Results

3.1 Subject demographics

Ninety PD patients underwent PET with two inflow volumes: 1500 ml (20 patients, group 1) and 2000 ml (70 patients, group 2). There were no differences in the distributions of age, gender, underlying diseases, or durations of PD treatment between the two groups (see Table 1).

===Table 1 inserted here===

3.2 Significant variables used in this study

We identified a set of variables that provided the best discrimination between the two groups (see Table 2). The discriminator variables providing the best discrimination are height, weight, BMI, WC, effluent volume, P0, and P4 in IPP. Only those five were significantly and practically extracted. That is, Student's t-test suggests that the two groups are statistically different at a significant level of 0.05 about the five variables mentioned above (see Table 2).

==Table 2 inserted here===

3.3 Formulas predicting inflow volume

3.3.1 EFA used for selecting domain variables using the original data

Two domains composed of (1) P0, P4, and “effluent volume”; and (2) BMI and waist circumference were observed by using EFA.

The three methods (i.e., alternatives from A to C in Table 3) used for discriminating the study groups are equivalently equal, with a high correct prediction rate (94.4%). The AUCs approach 0.98. The only difference results are from the standard errors(SE). See Figure 2. It is noting that the smaller SE(=0.01) is from Logistic regression (LG). The predicted variable using LG is Z (= 4.32974 + 3.85477 * F1 + 3.83008 * F2 based on the sample factor scores) for calculating optimal dialysate DV, see Table 3.

==Table 3 and Figure 2 inserted here===

We plotted the rotation axis with the two domain scores of 90 patients in Figure 3. It is evident from using the rotation method at 35 degrees of the angle that only five subjects were misclassified. All other equations (i.e., discrimination functions and logistic regression) have a high correlation (>0.97) with one of the rotation equations in Figure 3. As a result, the predicted accuracies of those classifications are similar (see Table 3). Interested readers are invited to san the QR-code in Figure 3 to see the EFA process for extracting factors and featured variables from the study data.

== Figure3 inserted here===

Figure 3 The plot of study data and a new axis of Z (new axis) for alternative A.

However, the personal factor scores are usually unknown when answering the app on a smartphone for classifying appropriate DV. The personal factor scores are thus required to be transformed from the original responses on the App.

3.3.2 Prediction accuracy using variables including effluent volume

Two Equations for obtaining the personal factor score are shown at Step D in Table 4 using multiple regression analysis to estimate model parameters. Through this, we can get an accuracy rate of 92.22% shown at Step E in Table 4.

However, the effluent volume might be a collinear variable to the predicted DV. Furthermore, patients are to know the appropriate DV without the previous record of eluent volume at the first treatment on PD. The accuracy rate using featured variables but eluent volume to predict types of the PD DV for patients is required.

==Table 4 inserted here===

3.3.3 Validation when Excluding the Variable of Effluent Volume

Due to the close relationship between the inflow and effluent volume as well as the new CAPD patients who have not the experience of applying the type of DV, step D in Table 5 was performed by using LG according to the sample factor scores. The accuracy rate is 89.47% and the ROC=0.976, see the bottom in Figure 2.

Similar to the previous section, the personal factor scores should be known by using the model parameters of multiply regression analysis at Step G in Table 5. That is, two factors were predicted by two respective equations with factor scores at step G. Parameters were derived from factor scores in EFA (i.e., P0 and P4 in Factor 1 and BMI and WC in Factor 2 for individual PD patients). Through this, the original patients using the validation data can be regrouped again by Steps H.

The prediction formula is thus determined at Step H (i.e., Z = 2.80498 + 2.41593 * F1 + 2.74587 * F2 with mode H in Table 3) developed excluding the variable of effluent volume. The correct prediction rate is 89.01% with AUC = 0.958, slightly lower than that, including effluent volume at the correct prediction rate of 92.22%, but much higher than the previous study at 80.68%[4].

==Table 4 inserted here===

3.4 An App for Determining DVs for PD patients

An app with a QR code as seen at the top in Figure 4 is demonstrated in Additional File 1. Interested readers are invited to scan the QR code in Figure 4 to see the group classification response when entering the required data (i.e., P0, P4, BMI, and WC [cm]) at the left-top corner at Step 1 in Figure 4.

The results are immediately shown on the screen at Steps 2 and 3 in Figure 4 according to the cutting point at 3.79, see Step H in Table 5 . If the effluent volume has been entered to predict DV jointly at Step 1in Figure 4, the next calculation for DV and the visual display are presented at Steps 3 in Figure 4. The confidence is denoted by the probability of the classification on the axis Y suggested for physicians who can adjust DV more specifically, not limited to either 1500 or 2000 ml, as was the case in daily practice.. For instance, the confidence(=probability) for classifying the DC of 1500 ml (on the curve 1500 ml) is 0.75 in Figure 4. higher than 0.5(or odds=1.0) at the intersection of these two curves, implying the tendency of the classification is toward 1500 ml instead of toward 2000 ml.

== Figure 4 inserted here===

4. Discussion

We studied the key factors affecting the maximum UF volume (i.e., P0, P4, effluent volume, BMI, and WC[cm]) using EFA to extract, which are different from those including ΔH4-H2, and ΔIPP in the previous study [4]. The latter two were reported and evident in this study without significance in statistics when performing independence t-test for examining the difference between the two study groups. The correct prediction rate was 80.86% less than the one including (94.4%) or excluding (89.01%) the effluent volume for this study.

4.1 What This Knowledge Adds to What We Already Knew

All PD physicians are required to help patients not only with removing uremic toxin but also controlling the volume status to improve patient outcomes [16-18]. We created an app as a reference to quickly and objectively determine the optimal DV for PD patients in conforming and safety zones.

The features of this study include (1) factor scores cause the accuracy higher than the traditional method using original raw scores as predicting variables; (2) the mode of excluding effluent volume has an accuracy slightly less than the mode of including effluent volume because of the collinearity exists in inflow and effluent volumes; (3) the personal factor scores are required to be transformed using the multiply regression analysis for each factor, particularly, used on an app for individuals.

4.2 What the Findings Imply and What Should Be Changed?

The discriminating probability of those three alternatives in Table 3 is identical, with an accuracy percentage of 94.4%, which is reached when the five variables determined by samples with appropriate variables to evaluate. Even though the computation can be easily performed at the hospital after obtaining the five values mentioned above using either one from A to C in Table 3, our recommended formula is the one applying mode H (excluding effluent volume) because of easy use for programing codes on an app. Otherwise, the factor scores that come from the standardized scores by computing the observed scores, means, and standard deviations in Table 2 and multiplying the respective factor score coefficient metrics in Additional File 3 are required in use for the app design and development.

Accordingly, we provide an app with the four entries, which is simple and easy for patients or their physicians to accurately predict the optimal inflow volume, 1500 ml or 2000 ml, for an individual patient. Traditionally, we determined the inflow volume using the two variables of waist circumference and BMI [4], which is insufficient and merely shows a lower correct prediction rate (80.68%).

4.3 Strengths of This Study

Referring to Figure 2, even if using other three classification methods based on two domains constructed by five or four variables in this study, the effectiveness is equivalent and identical (see Table 3), because close relations exist among those modes from A to C in Table 3.

Also, we recommend an app that makes it possible for physicians or patients to make frequent adjustments on DV in daily practice. Details about the process in use are shown with an MP4 video and a linkage in **Additional File**s.

Furthermore, the curves of category probabilities based on the Rasch rating scale model [19] are shown in Figure 4. The binary categories (eg, success and failure on an assessment in the psychometric field) have been applied in health-related outcomes [20-25]. However, none provided the animation-type dashboard showing on Google Maps, as we did in Figure 4.

4.4 Limitations and Future study

One of the limitations of this study was that only one set of measurements was obtained during the PET, which was performed regularly every six months. That is also the reason we recommend applying the formula for adjustment of daily DV by patients themselves to obtain maximal UF volumes. The sooner adjustments of DVs are made, the better the fluid control, which reduces mortality.

Readers may not be convinced that only two inflow volumes (1500 ml or 2000 ml) will suffice for clinical practice and meet most patients' needs. We suggest performing confidence calculation on the mobile app to aid PD physicians in determining the appropriate DV for multi-groups in clinical practice.

Another limitation is the small sample size (n = 90), which did not allow us to generalize the results to other places or populations. A greater number of subjects are required for future research. All study process and data are deposited in **Additional File**s for readers interested in replicating their research in the future.

Although other algorithms such as convolutional neural networks(CNN) have been proposed in practice before[25,27], we conducted a small study in an effort to include more variables(e.g., gender, age, body size, patient feed-back, achieved dialysis dose, etc.) in a CNN prediction model, but fail to gain a higher prediction accuracy than the one(=89.01%) we did in this study. Future studies regarding the use of artificial intelligence(AI) are encouraged to improve the prediction accuracy.

The way for accessing to the App is merely suggested to scan the QR code in Figure 4. The professionally practical App should be further developed for android and IOs in future.

4.5 Conclusion on the classification of DV for PD patients.

The contributions in this study consist of three parts: (1) using factor scores to increase the prediction accuracy in comparison to the previous study using traditional raw-scores summation method; (2) applying the mode of excluding effluent volume to the app we designed in Figure 4 for helping physicians and PD patients determine appropriate dwell volume; (3) transforming personal responses into their factor scores on domains to reach a higher accuracy in DV classification.

We thus provide a novel formula combined with an app using objective, real-time parameters for predicting appropriate DVs for PD patients was proposed to optimize maximal ultrafiltration volumes and reduce subjective abdominal discomfort. The app makes the frequent adjustment of daily DV by physicians or patients easy to calculate.

Abbreviations

AUC= area under the curve, BMI= body mass index, CAPD= continuous ambulatory peritoneal dialysis, DF= Discrimination Function, DV= dwell volume, EFA= Exploratory factor analysis, ESRD= end-stage renal disease, F1=the first-factor score, F2=the second-factor score. 1IPP= intraperitoneal pressure, LR= logistic regression, P0= IPP before dialysate instilled. P4= IPP after four hours, PD=peritoneal dialysis, PET=peritoneal equilibration test, ROC= receiver operating characteristic curve, UF= ultrafiltration, VBA=visual basic for application, WC= waist circumference

Declarations

Ethics approval and consent to participate

Not applicable.

All data were requested from the authors of the previous study.

Consent to publish

Not applicable.

Availability of data and materials

All data used in this study is available in **Additional File**s.

Competing interests

The authors declare that they have no competing interests.

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Authors' Contributions

TW conceived and designed the study, CC and WC interpreted the data, and TW monitored the process and the manuscript. HY drafted the manuscript. All authors read the manuscript and approved the final manuscript.

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Tables

Table 1 Demographic data of study subjects (n = 90)

	1500 ml		2000 ml		Total		*p*
	n	%	N	%	n	%	
Gender							0.088
Female	18	90.0	50	71.4	68	75.6	
Male	2	10.0	20	28.6	22	24.4	
Age [year-old]							0.515
<40	4	20.0	9	12.9	13	14.4	
40–50	5	25.0	27	38.6	32	35.6	
>50	11	55.0	34	48.6	45	50.0	
Underlying disease							0.535
DM	2	10.0	11	15.7	13	14.4	
CGN	17	85.0	55	78.6	72	80.0	
CIN	0	0.0	3	4.3	3	3.3	
SLE	1	5.0	1	1.4	2	2.2	
CAPD duration [month]							0.429
<12	8	40.0	18	25.7	26	28.9	
12–36	2	10.0	17	24.3	19	21.1	
36–60	5	25.0	15	21.4	20	22.2	
>60	5	25.0	20	28.6	25	27.8	

Table 2 Variables compared with two groups of 1500 ml and 2000 ml

	Group 1 (n = 20)		Group 2 (n = 70)		*t*	p
	Mean	SD	Mean	SD		
Height (cm)	77.60	8.95	86.21	9.21	3.91	<.001
Weight (kg)	47.48	7.63	59.09	9.40	5.01	<.001
WC[Waist circumference (cm)]	77.60	8.95	86.21	9.21	3.71	0.001
BMI	20.45	2.91	23.26	3.33	3.42	0.001
Effluent volume (ml)	1779.00	140.56	2277.86	172.45	11.85	<.001
P0 for IPP	1779.00	140.56	2277.86	172.45	6.09	<.001
P4 fpr IPP	1271.60	178.01	1424.35	165.67	3.58	0.001

Table 3 **Comparison of methods including effluent volume using sample factor scores**

		Observed		Correct	AUC for ROC	Cutting	Sensitivity
Alternatives	Predicted	**1500**	2000	%	95% CI	Point	Specificity
A							
Rotation axes	1500	18	3	94.44	0.981	>-0.47	0.94
On sample FS	2000	2	67		0.927 - 0.998		1
Prediction Formula	Z =0.848 * F1 +0.529° * F2 at 35				degree of the rotated line		
B							
DF	1500	18	3	94.44	0.981	>0.784	0.94
On sample FS	2000	2	67		0.927 - 0.998		1
Prediction Formula	Z=1.339*F1+0.947*F2						
	Z0=-4.447+(-3.248)*F1+(-2.297)*F2						
*Max(Z0,Z1)	Z1=-0.491+(0.928)*F1+(0.656)*F2						
C							
LG	1500	18	3	94.44	0.984	>1.299	0.93
On sample FS	2000	2	67		0.931 - 0.999		1
Prediction Formula	Z=4.32974+3.85477*F1+3.83008*F2						

Note. DF: Discrimination Function; LG: Logistic regression

Table 4 **Using LG to predict DV including effluent volume using factor scores(FS)**

		Observed		Correct	AUC for ROC	Cutting	Sensitivity
Alternatives	Predicted	1500	2000	%	95% CI	Point	Specificity
D							
F1 & F2 predicted	F1=-9.503+0.002*IPP4+0.003*IPP0+0.001*Effluent volume						
	F2=-7.813+0.162*BMI+0.049*Waist						
E							
LG	1500	16	4	92.22	0.981	>1.297	0.914
On personal FS	2000	3	67		0.927 - 0.998		1
Prediction Formula	Z=7.92889+4.38171*F1+3.56082*F2						

Figures

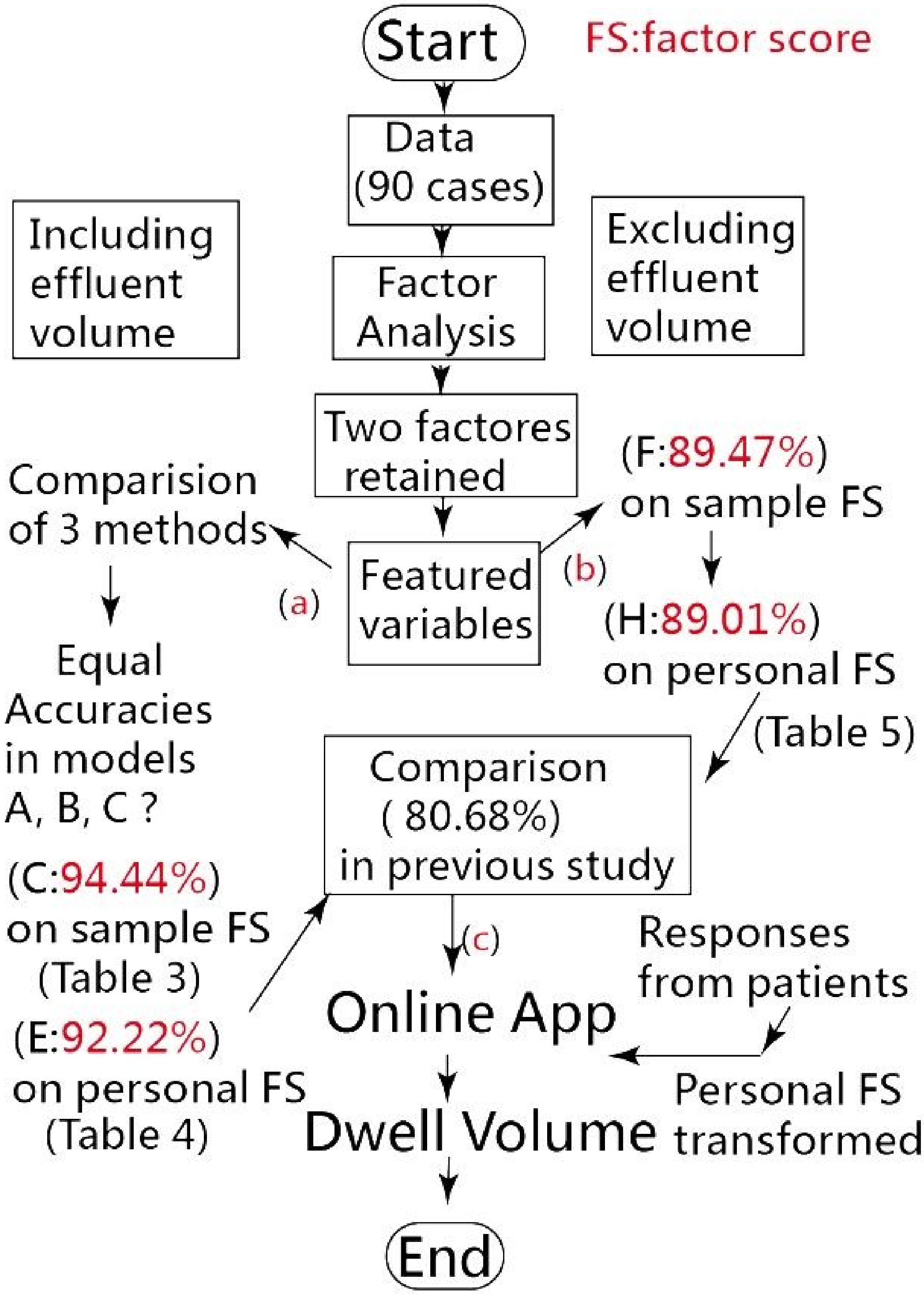

Figure 1

Study flowchart

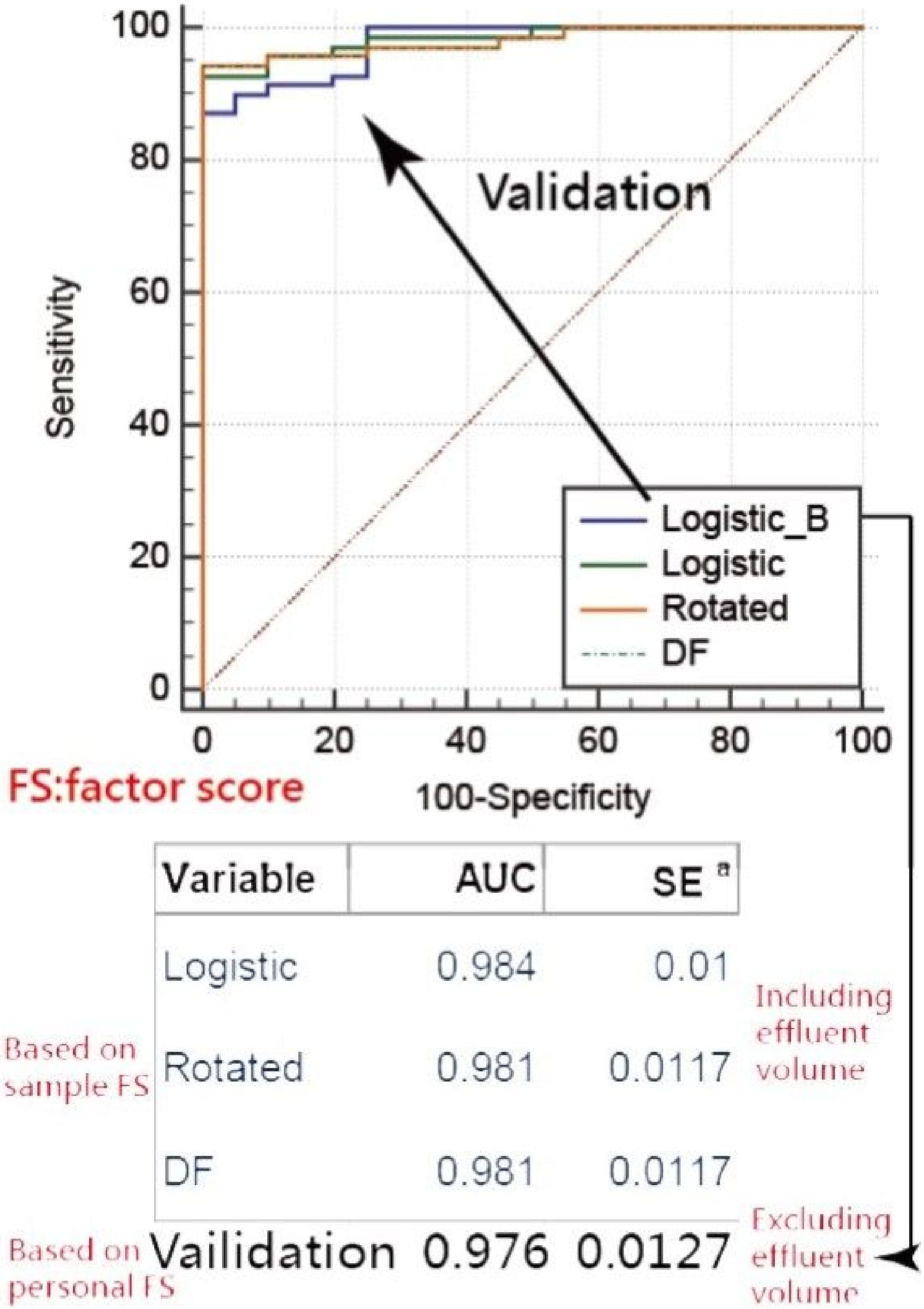

Figure 2

Comparison of scenarios for the AUCs of ROC curves

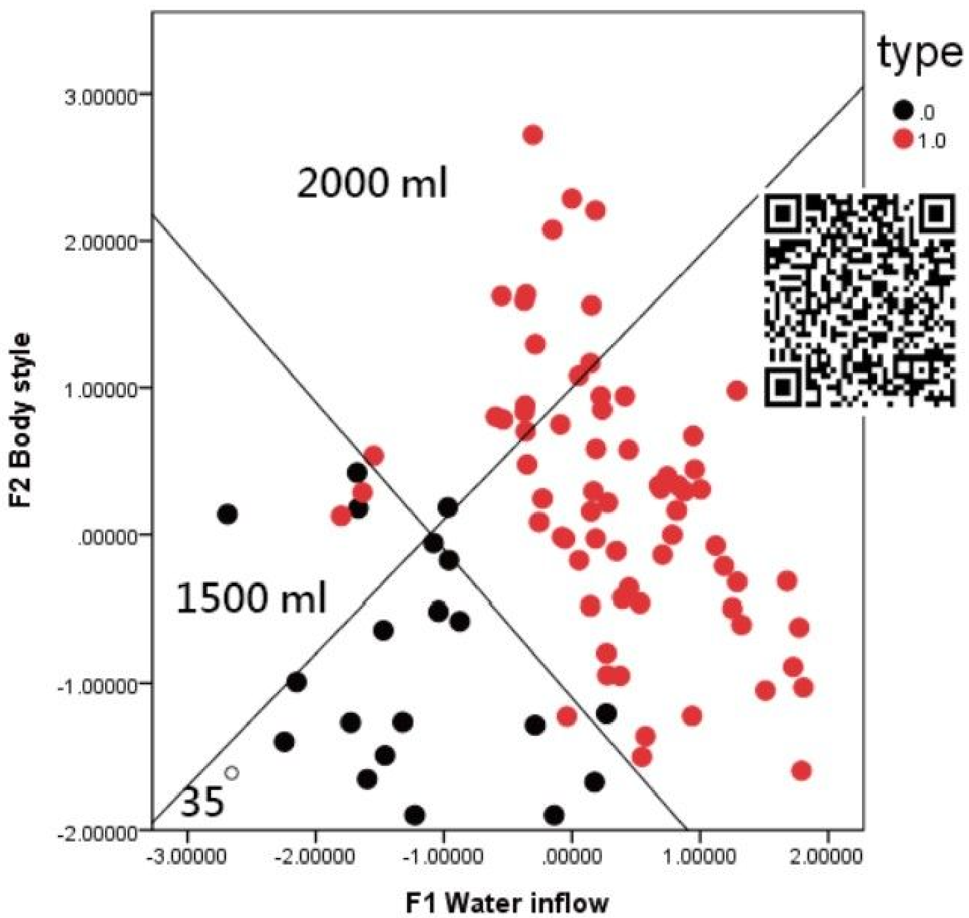

Figure 3

The plot of study data and a new axis of Z (new axis) for alternative A.

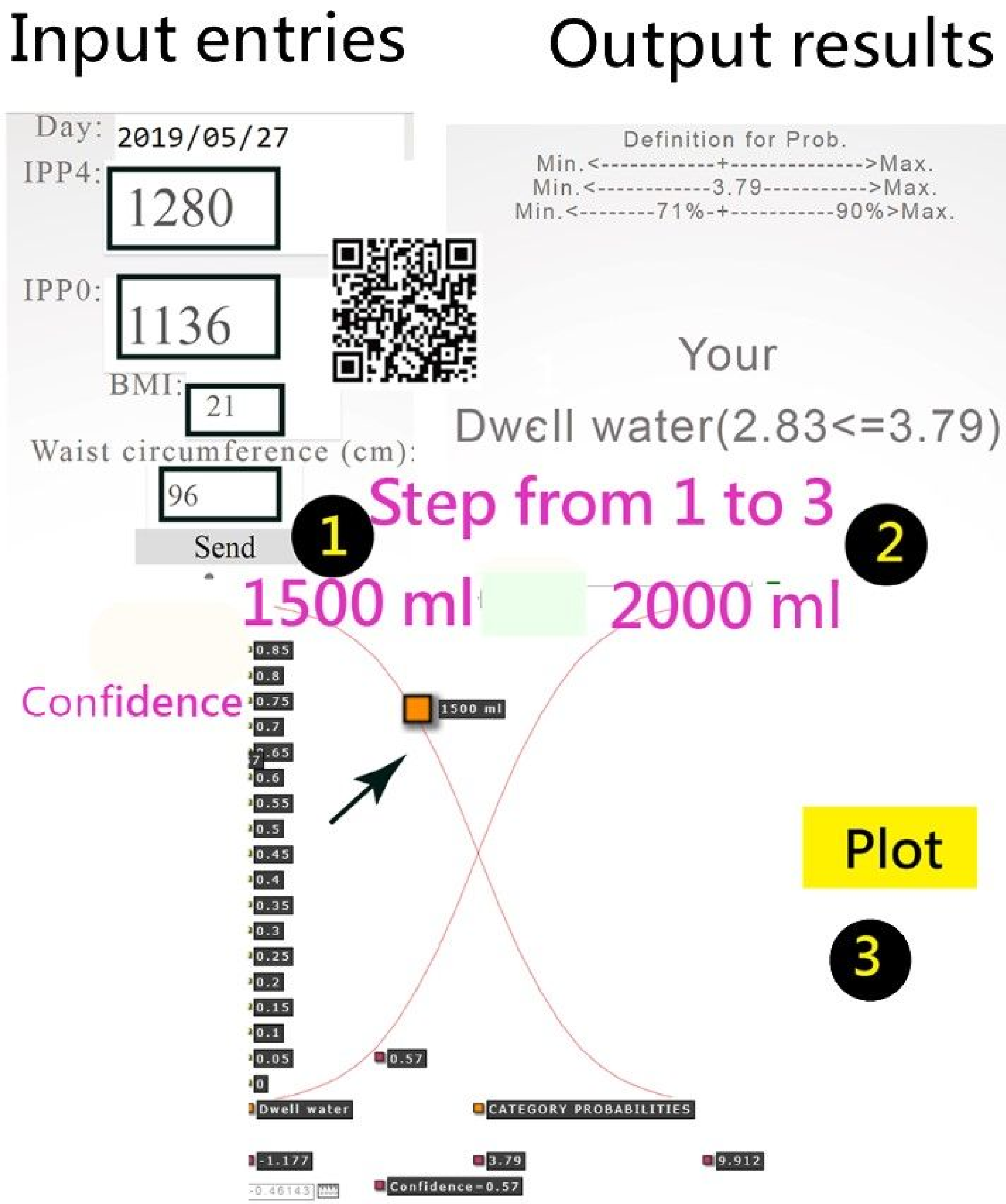

Figure 4

The mobile APP used in this study

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- dataset22.xlsx
- SupplementalDigitalContentfile3.docx
- Multimediafile2.docx