"Raw" Formula for Calculating Maintenance Fluid Volumes in Low Birth-Weight and Premature Babies Derived

Type of Article: Original

Nwate Ledisi

Department of Anesthesiology, Braithwaite Memorial Specialist Hospital,Port Harcourt, Nigeria.

ABSTRACT

BACKGROUND

Fluid management of low birth weight and preterm babies can be challenging, as the determination of maintenance fluid volumes have to be calculated to suit the demands of this delicate neonates in order to avoid fluid over-load or dehydration. It is on this background that this study to derive an easy to use formula for calculating maintenance fluid volumes in this category of babies was embarked upon, utilizing existing Tables.

METHOD

One of the most developed Tables on this subject matter, the 'Paediatric Surgical Unit Guidelines, Sheffield Children's Hospital' was selected, re-ordered, subjected to analysis, factorization and simplification; in order to derive the formula. To validate its accuracy the Table was re-constructed using the derived Formula. The derived Table was then compared with the original table. The paired sample T- test, using variation in days and in weights, did not show any statistically significant ($p<0.05$) difference between the two Tables

RESULTS

From the Table the formula, 20{(R+A)-W}, ml kg^{-1} day^{-1} was derived. This translates to 20(R+A-W) ml kg^{-1} day^{-1} or 0.8(R+A-W) ml kg^{-1} Hr^{-1}. Where:

R = Rehydration factor (ranging mostly from 3 to 5), A = the age (in days) of the baby, W = premature baby's actual weight. These three letters constitute the acronym, RAW.

CONCLUSION

It is recommended that "RAW" Formula be used in Calculating Maintenance Fluid Volumes in Low Birth-Weight and Premature Babies. This is because its accuracy is validated; having compared and noted that there is no statistically significant difference between the tables constructed from it with the original PSU Sheffield Table.

KEYWORDS

RAW Formula; Maintenance Fluid Volume; Premature; Low Birth Weight Babies

Correspondence: Dr L. Nwate
Email: ledisinwate2@gmail.com

INTRODUCTION

Intravenous fluids are given for resuscitation to correct pre-existing dehydration and hypovolemic status. As maintenance for replacing normal ongoing losses e.g to provide water, electrolytes and glucose during periods of ill health and starvation, and for replacement of ongoing abnormal losses due to evaporation from an open wound or via the humidification of dry inspired gases, bleeding, pyrexia, gastrointestinal and third space losses (fluid leak into tissues).

Among the three reasons only maintenance fluid is needed on continuous basis; even in the absence of pathology in the individual.

While there is a set of Formulas, referred to as '4:2:1' rule [2-6] for calculating maintenance fluid volumes for adults and older children (Table 1)[2,5,] there is none for premature and low birth-weight babies.

Table 1:SET OF FORMULAS, REFERRED TO AS THE "4:2:1" RULE	
For Body weight	Give Maintenance fluid rate/volume
< 10 kg	4 ml/kg/hour
10-20 kg	40 ml + 2 ml/kg/hour
> 20 kg	60 ml + 1 ml/kg/hour

Premature[7] birth is defined either as preterm birth or the birth of a baby before the developing organs are mature enough to allow normal postnatal survival. In humans preterm birth (Latin: partuspraetemporaneus or partuspraematurus) is the birth of a baby of less than 37 weeks gestational age[8.9].

There are sub-categories[8] of preterm birth , based on gestational age (GA): Extremely Preterm , referring to those less than 28 weeks GA; Very Preterm, for those between 28 and 32 weeks; and Moderate to Late Preterm, for those between 32 to 37 weeks. Preterm birth is the second largest direct cause of child deaths in children younger than 5 years[9].

Excess fluid administration in the very low birth weight infant has been associated with patent ductus arteriosis and congestive heart failure, intraventricular hemorrhage, necrotizing enterocolitis and bronchopulmonary dysplasia[10]. On the other hand, infants and children are sensitive to small degrees of dehydration[11].A lot of work,[12-15]therefore, had been done in order to estimate correct maintenance fluid requirement for preterm infants. Such studies include those on body fluid compartments[16,17]; on changes during transition from intra –uterine to extra-uterine life, environmental humidity and its effect on daily insensible loses. The result of such studies had shown that many factors do influence fluid balance in preterm babies. Such studies also showed that, unlike in adults, extra-cellular fluid (ECF) constitutes a large proportion of the fetal body composition; and reduces abruptly soon after birth, causing weight loss. In addition, it also showed that, in utero, the pulmonary vascular resistance (PVR) is high; but that at birth lung expansion causes a drop in PVR, allowing an increase in pulmonary blood flow. Increased blood flow from the lungs then stretches the left atrium and stimulates secretion of atrial natriuretic peptide (ANP) causing sodium loss, diuresis and weight loss; with the negative sodium and water balance lasting for 2–4 days. Consequently, an early administration of sodium would inhibit postnatal adaptation and delay the reduction of the ECF.It has also been shown from such studies[16,17] that Preterm kidneys have lower Glomerular Filtration Rates (GFRs), and fewer ion transporters; and therefore, have less ability to both excrete and reabsorb sodium and water.

Trans-epidermal water loss (TEWL); the continuous passive diffusion of water through the stratum corneum[18] is known to decrease with rising gestation and increasing postnatal age. TEWL alone can be as high as 140ml/kg/d during the first few days of life in a 24-26 week neonate. Nursing an infant in a humid environment reduces TEWL, and a reduction from 140ml/kg/d to less than 40ml/kg/d can be achieved by keeping the incubator humidity at 90%.

The recommendation from studies for the maintenance of fluid state that in prescribing[19] fluids one should usually start at 80-100ml/kg/day, and increase progressively to a target of 180ml/kg/day. It is however expected that adjustments should be made according to clinical and laboratory findings. For example, clinical peripheral oedema may signify fluid overload while reduced skin turgor would signify dehydration. The latter, however, is usually a late sign in the neonate. In addition rapid weight changes would suggest water loss or gain. Urine output, if excessive, may inform one of the needs to consider giving more fluid. Reduced urine output, on the other hand may signify either dehydration or poor renal function. These two conditions require different fluid prescriptions, so urine output should not be considered in isolation. Changes in Serum Sodium levels may signify water loss or gain or sodium loss or gain. Hypernatremia in the first few days is usually caused by dehydration. In management of fluid balance in neonate U&E's may need to be measured 8-12 hourly initially.

The delicate balance in the maintenance of water and electrolyte in neonates especially preterm babies indicate that fluid maintenance in this age group has to be guided by the dynamics of the peculiar physiology of fluid and electrolyte balance in the age group. This makes guideline and tools which guide fluid prescription in the group of patients very useful. It is in line with these objectives that the outcome of some studies[15-18] resulted in the table (Table 2)[2,5,12-15] which guides the prescription of maintenance fluid in preterm and low birth weight babies. It should be noted that this table serves as a guide and individual clinical assessment is always important in making clinical decisions.

TABLE 2:BASELINE FLUID REQUIREMENTS ML/KG/DAY

DAY	BT WT <1.5KG Total Volume (ml/kg/day)	BT WT >1.5KG Total Volu me (ml/kg/day)
1	80	60
2	110	90
3	130	110
4	160	140
5	170	150
6+	180	160

A more comprehensive Table dealing with this subject matter is that of Sheffield Children's Hospital(Table 3)[1,2].

Table 3:Paediatric Surgical Unit Guidelines, Sheffield Children's Hospital

Weight / age	< 1.0 kg	1.0 – 1.5Kg	1.5- 2 Kg	> 2.0 kg
Fluid	Requirement	ml/kg/day		
Day 1	100 – 120	80 – 100	60-80	40 – 60
Day 2	120 – 150	110 – 130	90-110	60 – 90
Day 3	150 – 170	140 – 160	120-140	80 – 100
Day 4	180 – 200	160 – 180	140-160	100 – 120
Day 5 and after	180 – 200	170 – 200	150-180	120 - 150

A closer look at existing Tables reveals a predictable relationship between the stated Fluid Volumes, the Age and the weight of these babies. This granted the conviction that formula derivation from them is a possibility. The desire to derive a Formula for calculating maintenance fluid volumes in neonates /low birth-weight and / premature babies (in place of Tables) therefore became the driving force behind this work.

METHOD

Tables used in different institutions, as published in different papers and relevant articles, were studied.(Tables 2-5). Among them were those from Sheffield Children's Hospital, Starship Medical Center, Scott Mosses Family Practice Notebook and protocol on same topic from All India Institute of Medical Sciences (AIIMS) Division of Neonatology, Department of Pediatrics.

Table 4: Starship Hospital (surgical or medical services [ml/kg/day]

	Day 0-1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7+
<37 weeks	60	75	90	105	120	150	180
37 weeks+	60	75	90	105	120	120	150

Table 5:Scott Moses, MD, Family Practice Notebook 2012

Weight <1000 grams • Adjust fluid requirements for insensible water loss • Fluid requirements may range up to 200 ml/kg/day Weight >750 grams • Day 1-2: 105 ml/kg/day • Day 3-15: 140 ml/kg/day Day >15: 150 ml/kg/day Weight >1000 grams • Day 1-2: 100 ml/kg/day • Day 3-15: 130 ml/kg/day Day >15: 140 ml/kg/day	Weight >1250 grams • Day 1-2: 90 ml/kg/day • Day 3-15: 120 ml/kg/day • Day >15: 130 ml/kg/day Weight >1500 grams • Day 1-2: 80 ml/kg/day • Day 3-15: 110 ml/kg/day • Day >15: 130 ml/kg/day

The method involved studying and noting the similarities within all the available Tables. Similarities noted on the Tables were that the volumes of required maintenance fluid depended on the age and the weight. .

Again the study included noting the differences between the available Tables. The latter study revealed that, though the maintenance fluid volumes for babies of the same weight from the different Tables / institutions were not exactly the same, they were not too different from one another. Those institutions that their volumes differed much from the others were noticed, rather, to be utilizing what is termed Restricted Fluid regimen[20].

It was also noted that some Centers/ Institutions were utilizing what would be regarded as part of a more comprehensive table. For example, Starship Hospital's Table could be seen as reflecting itself on Sheffield

Hospital's Table in the column under > 2 kg . A closer look at Scott Moses, Family Practice Notebook tables indicated that (between Days 1 to 5) these tables in most instances, utilized volumes that were used in the Sheffield table.

Having gone through these Tables / Protocols, Pediatrics Surgical Unit Guidelines of Sheffield Children's Hospital was seen to be(one of) the most developed on this subject matter. Consequently it was selected and subjected to analysis, factorization and simplification until the Formula was derived. The derived Formula was thereafter used to reconstruct a new Table for validation of the formula.

RESULTS

The initial Formula derived, using Sheffield's Table was 20{(5+A) –N}; where A is the baby's age in Days; and N, the Nominal weight of the baby. N was assigned to the baby, based on weight range into which the baby's weight fell.

Soon after this derivation it was discovered that the actual weight of the baby (W) could be used in place of the nominal weight (N) without any significant difference in results. Consequently, the Formula was re-written as 20{(5+A) –W}ml/kg/day.

The figure, 5, in the Formula was seen to be a constant. At this stage the formula was re-written as 20{(K+A) –W}ml/kg/day; where K is the constant.

Following the rule of BODMAS[21] in mathematics, the formula was further modified to 20(K+A –W) ml/kg/day.

Quantitatively reasoning, it became clear that in any particular baby (with known/fixed weight and age) any unit decrease in value of the Constant, K, would reduce the required maintenance volume of fluid by 20mls.Since those Institutions using Restricted fluid Regimens utilized fluid volumes that were less (than those used in Sheffield) by multiples of 20mls it became evident that the difference between Liberal and Restricted fluid regimens laid in the value of K. The higher the value of K (towards 5) the more liberal the fluid regimen; and the smaller the value of K (towards 0), the more restricted the regimen. The constant was therefore named Hydration/ Rehydration (R)factor. The formula now took the form, 20(R+A–W) ml/kg/day.

To get an hourly maintenance fluid volume, the fluid volume per day had to be divided by 24. The Formula therefore has its hourly equivalent / version written as 20/24(R+A–W) ml/kg/hr. or 0.8(R+A–W) ml/kg/hr.

Re-construction of the Table using the derived Formula. Re-constructing the Table using the derived Formula, Table 6 was obtained.

Table 6: By Formula, 20(R+A –W) ml $kg^{-1}Day^{-1}$

Weight / Age Weight/Age	0 – 1.0 Kg 0 -1.0 kg	1.0 -1.5Kg 1.0-1.5kg	1.5 -2.0kg 1.5-2.0kg	3>2kg- (3-4kg) g
Fluid requirement		ml/kg/day		
Day 1	120-100	100-90	90-80	60-40
Day 2	140-120	120-110	110-100	80-60
Day 3	160-140	140-130	130-120	100-80
Day 4	180-160	160-150	150-140	120-100
Day 5	200-180	180-170	170-160	140-120

One important feature noticed on the reconstructed table (Table 6)was that the fluid volumes were automatically displayed in a descending order. It clearly revealed the fact that the lighter or more premature a baby is, the more the maintenance fluid requirement would be. The Table obtained through the Formula, therefore depicted a more natural tendency with regards to maintenance fluid requirement in this category of babies.

The reconstituted table also showed that the babies who were meant to be > 2.0 kg in the original table (Table 3)were precisely those weighing between 3-4kg.

Reconciliation/Harmonization of the Tables.

While the original Table shows the fluid volumes displayed in an ascending order, the fluid volumes on the reconstructed Table (using the Formula) naturally got displayed in the descending order. Table 7 shows fluid volumes from original (Table 3) compared/

apposed with those from Table 6 ; the latter in parenthesis. Table 7 was therefore regarded as un-harmonized.

Table 7: Fluid volumes from original (Table 3) compared/ apposed with those from Table 6 (in parenthesis); un-harmonized

Weight / Age Weight/Age		0 – 1.0 Kg 0 -1.0 kg	1.0 -1.5Kg 1.0-1.5kg	1.5 -2.0kg 1.5-2.0kg	3->2kg 4.0Kg [3-4]kg
Fluid requirement			ml/kg/day		
Day 1	100 – 120 [120-100]		80 – 100 [100-90]	60-80 [90-80]	40 – 60 [60-40]
Day 2	120 – 150 [140-120]		110-130 [120-110]	[90-110] 110-100	60 – 90 [80-60]
Day 3	150 – 170 [160-140]		140 – 160 [140-130]	120-140 [130-120]	80 – 100 [100-80]
Day 4	180 – 200 [180-160]		160 – 180 [160-150]	140-160 [150-140]	100 – 120 [120-100]
Day 5	180 – 200 [200-180]		170 – 200 [180-170]	150-180 [170-160]	120 - 150 [140-120]

To enable an easier visual comparison between fluid volumes from the two sources on Table 7, the display has to be in the same order : either in the ascending or in the descending order. Table 8 became the outcome of displaying Table 7 in the same (descending) order. Table 8 is therefore called harmonized.

Table 8: Fluid volumes from original /Sheffield Table and those from the Formula (in parenthesis) were arranged in the same descending order: harmonized.

Weight/Age		0 -1.0 kg	1.0-1.5kg	1.5-2.0kg	>2[3-4]kg
Fluid requirement			ml/kg/day		
Day 1	120 – 100 [120-100]		100 – 80 [100-90]	80-60 [90-80]	60 – 40 [60-40]
Day 2	150 – 120 [140-120]		130-110 [120-110]	[110-90] 110-100	90 – 60 [80-60]
Day 3	170 – 150 [160-140]		160 – 140 [140-130]	140-120 [130-120]	100 – 80 [100-80]
Day 4	200 – 180 [180-160]		180 – 160 [160-150]	160-140 [150-140]	120 – 100 [120-100]
Day 5	200 – 180 [200-180]		200 – 170 [180-170]	180-150 [170-160]	150 - 120 [140-120]

Validating the formula: The paired sample T-test using variation in days and in weights was applied to test for significance and validity. No statistically significant ($p<0.05$) difference was found between the Original (Table 3) and the Reconstructed (Table 6).This test of significance was also done by using the harmonized Table 12; computing and comparing the 'ranges without parenthesis' with those 'within parenthesis'.

Another way of demonstrating the validity of the derived Formula was by comparing the Fluid Range that is allowable based on the baby's Age (in Days) on the original (Table 3) with that obtainable using the Formula (Table 6). Table 9 shows the allowable fluid volumes for each day of life (A –from Sheffield, and B-from the formula).For example, the allowable fluid volume forday-1 babies is 40 to 120 ml/kg/day; and for day-2 is 60 to 150 ml/kg/day. Computing the figures on Table 9, between A and B also revealed that there was no statistically significant difference between them.

TABLE 9:Fluid Range on each Day

	A		B	
DAY	From Sheffield [Volume In ml/kg/day]		From Formula[Volume In ml/kg/day]	
	< 1.0 kg	> 2.0 kg	< 1.0 kg	> 2.0 kg [3-4kg]
1	120	40	120	40
2	150	60	140	60
4	170	80	160	80
4	200	100	180	100
5	200	120	200	120

The validity of the derived formula was also demonstrated by comparing the maintenance volume requirements per hour (as reflected on Sheffield's Easy conversion Table[1] (Table 10) with those obtained using the Formula (Table11)

Table 10: EASY CONVERSION TABLE – Sheffield's

ml/kg/day	ml/kg/hr.
40	1.7
60	2.5
80	3.3
90	3.5
100	4
120	5
150	6
180	7.5

Again, there was no statistically significant difference between the volumes in ml/kg/hr. on Tables 10 and 11.

TABLE 11: Volume In ml/kg/hr. using the RAW Formula

R	AGE	WT		0.8(R+A-W) ml/kg/hr.	20(R+A-W) ml/kg/day.
4	1	3	=>	1.6	40
4	2	3	=>	2.4	60
4	3	3	=>	3.2	80
4	4	3.5	=>	3.6	90
4	5	4	=>	4.0	100
4	6	4	=>	4.2	120
4	7	3.5	=>	6.0	140
4	8	3	=>	7.2	180

Table 12 is Tables 10 and Table11 constructed as one.

Table 12: Hourly maintenance volume requirements, compared.

Age	Those from Sheffield's Easy Conversion Table compared with those using the derived Formula (in parenthesis)
1	1.7(1.6)
2	2.5 (2.4)
3	3.3 (3.2
4	3.5 (3.6)
5	4 (4.0)
6	5 (4.2)
7	6 (6.0)
8	7.5 (7.2)

DISCUSSION

A formula is a special type of equation[22] that shows the relationship between different variables. A variable is a symbol like x or v that stands in for a number we don't know yet. It is a concise way of expressing information symbolically as in a mathematical or chemical formula. The plural of formula can be spelled either as formulas or formulae[23] (from the original Latin).Generally formulas are written as single-line equations and are constituted of symbols. There is need to contribute this fact: that while an equation shows a relationship between variables, a mathematical Formula is an equation constituted to solve a problem; and this is what makes it special as an equation. The benefit of using formulas is that most times they are less bulky and therefore easier (than Tables) to commit to memory. Because they do not give answers in ranges, results from them are usually more specific; which implies a higher degree of accuracy. Based on these reasons they are more preferred to Tables in the sciences, and are also more acceptable as research tools. The derived RAW formula produced from this study has these qualities.

It is no gainsaying that accuracy is very much needed in calculating fluid volumes for neonates, particularly the premature /low birth-weight babies. Without digging deep into physiology, it is glaringly clear that their small sizes make them more vulnerable to fluid overload. This implies that utilizing Tables (that permit the use of fluids in ranges) might not be the best.

Again, if a set of formulas, referred to as the " 4:2:1" rule[1] exist for Adults and older children, then there is a more pertinent reason why there should be one for the newborn / premature /low birth-weight babies . The existing "4-2-1" formula ,unfortunately, could not be extended to neonates/premature/ low birth weight babies .This is because the latter has a higher maintenance fluid requirement per kilogram body- weight; the explanation being that they are born physiologically "waterlogged"; only to lose this much fluid over the first week of life. They are also known to have a larger surface area to weight ratio1; so that they tend to lose more fluids by evaporation.

Useful findings with the formula

One striking finding revealed by the Formula was that the heavier the baby the lesser the amount of Maintenance fluid Volume required. With it became possible to prove that Volumes of fluids for babies weighing 2-3kg cannot be the same with those weighing 3-4kg Another finding, revealed by this formula, was that the weight of this category of babies cannot exceed 4kg. This is because 40mls, being the least amount of maintenance fluid volume allowable, corresponds to the greatest weight of any newborn baby on these Tables. And the greatest weight as revealed through the Formula is 4 kg.

Another useful finding was that the formula, unlike the Tables, was found to be far easier to recall/remember.

Yet another striking finding was the existence of the Rehydration factor within this formula. This factor tells by how much a baby is loaded with fluid i.e. hydrated/ rehydrated. Those institutions that are more liberal in giving maintenance fluid volumes are discovered to have been inadvertently using a high rehydration factor; of about 5. On the other hand, those institutions that have been using restricted fluid regimens are discovered to have been using lower values rehydration factors; about 2,3 or 4.

The Rehydration factor that had been used by an institution/ Center can be determined by a mathematical analysis of the Centre's Table. Since each institution tends to claim that its protocol was designed after evidence -based practice, the value of R differing from center to center, implies that the value of R can be correct within a certain range. The numerous elements: TEWL, Humidity, availability of incubators etc. of course, will likely influence the choice / value of R. For example, in certain developing countries within the tropics where facilities may be inadequate, a high value of R would be needed to compensate for a high TEWL; latter to be reduced during the humid rainy season. It is not surprising, therefore, that Sheffield used to review its protocols /Tables periodically (1). With the existence of the Formula such reviews, with regards to maintenance fluid volumes, will simply involve adjusting the rehydration factor (R), having considered the contributory elements.

It can be noted that whereas the original/ Sheffield's Table revealed a rehydration factor of 5 as shown in the derived formula, certain picked-out volumes on their Easy Conversion Table revealed a rehydration factor of 4 (Table 11). The implication of this is still to inform us that rehydration factor has a value that falls within a range. So it can be said that the rehydration factor used in Sheffield revolved around 4 and 5.

Examples on how to calculate maintenance fluid volumes, using the formula.

Having derived the RAW formula, can it be used in calculating fluid volumes without referring to Tables? Yes. How? The following questions will illustrate.

Question 1: What will be the maintenance fluid requirement for 3-day-old 3 kg baby that was delivered pre-term? [Given, that your center uses a rehydration factor of 5]

Answer: Using the *formula 20(R+A-W)* ml kg^{-1} day^{-1} the volume will be 20(5+3-3) ml kg^{-1} day^{-1}=100 ml kg^{-1} day^{-1} . The required volume on hourly basis will be 0.8(R+A-W) ml^{-1} kg^{-1} Hr^{-1} = 0.8(5+3-3) ml^{-1} kg^{-1} Hr^{-1} = 4 ml^{-1} kg^{-1} Hr^{-1}.

Question 2: What will be the maintenance fluid requirement for 2-day-old 1.8 kg premature baby? [Given, that your center uses a rehydration factor of 5]

Answer: Using the *formula 20(R+A-W)* ml kg^{-1} day^{-1} the volume will be 20(5+2-1.8) ml kg^{-1} day^{-1}=104 ml kg^{-1} day^{-1}

The required volume on hourly basis will be 0.8(R+A-W) ml^{-1} kg^{-1} Hr^{-1} = 0.8(5+2-1.8) ml^{-1} kg^{-1} Hr^{-1} = 4.2 ml^{-1} kg^{-1} Hr^{-1}.

It should be noted that the guiding principles with regards to selection of intravenous fluid-type and administration of electrolytes are still the same as when the Tables are used; frequent clinical and laboratory monitoring being essential. With regards to electrolytes these protocols recommend that Sodium and potassium should be added to iv fluids after 48 hours of post natal life; each in a dose of 2 to 3 meq/kg/day. Calcium in a dose of 4ml/kg/day [40mg/kg/day]16.

Usefulness of the formula

The RAW Formula can be used to calculate correct maintenance fluid volumes for preterm babies. It can also be used to assess the adequacy, or otherwise, of prescribed maintenance fluid volumes in a particular center. Having known their own approved rehydration factor, a prescribed maintenance volume can be assessed to be correct or wrong by simply using the formula.

Again the formula is useful in every Centre, whether such a Center uses Liberal Fluid or Fluid Restriction regimen. Centers using Liberal fluid regimen are those centers with a rehydration factor of 5 (or slightly less) ; while with restricted fluid regimen those using rehydration factors less than 5 (by a unit or more).

Given the age (A), weight (W) and the maintenance fluid volume (V) that a center uses, the rehydration (R) factor for that center can be known. This is because, since V = 20(R+A-W), then R must be 0.05V-A+W.

The formula is also useful in allowing comparative studies of fluid volumes administered to preterm babies in different centers. For example, the Fluid volume used in Starship Hospital (Table 12-I) for all their babies are noticed to be recommended to only neonates weighing more than 2.0kg in Sheffield. Such volumes were not used for babies weighing less than 2kg in Sheffield. The formula also supports the fact that such volumes are for babies above 2kg (Table 12 III & IV).

TABLE 12:The Formula: usable by both advocates of Fluid Restriction and Liberal Fluid giving regimens.

I		II	III	IV
Starship's		Sheffield's [> 2.0 kg]	Formula 20(R+A-W) R=3.5 to 4.5, Wt.= 2.5Kg	Formula 20(R+A-W) R=5, Wt.= 3-4Kg
Day 1	60	40- 60	60-40	60 -40
Day 2	75	60-90	80-60	90-60
Day 3	90	80 – 100	100-80	100-80
Day 4	105	100-120	120-100	120-100
Day 5	120	120-150	140-120	140-120

Another example can be taken from the All Indian Institute of Medical Sciences intensive care (AIIMS -ICU) protocol. In this protocol it was concluded that normal maintenance fluid required for new born son the first day would range from 2.5 to 3.5 ml/kg/hr; that this volume would increase to 5 - 6 ml/kg / hr. by the end of the first week; and to 7 -8 ml/kg /hr. thereafter24.

Using the RAW formula a 3kg preterm baby on day-1 will need 0.8 (5+1-3) ml/kg/hr. = 2.4ml/kg/hr. For a 5-day old preterm baby weighing 3kg the formula gives a volume of 0.8(5+5-3) = 5.6 ml/kg/hr. Per day the latter comes up to 20(5+5-3)=140ml/kg/day; which corresponds to what Sheffield uses (Table 3).

For a term baby the rehydration factor used should be lower; as low as 3 or 4. That means the volume required for a 3kg term baby on day-1 will lie within a range spanning from 0.8 (3 +1-1)ml/kg/hr., which is 2.4 ml/kg/hr. to 0.8(4+1-1)ml/kg/hr., which is 3.2 ml/kg/hr.

For a term baby, e.g., a day-5 term baby weighing 4kg, the fluid requirement should lie within the range from 0.8 (3+5-1) ml/kg/hr., which is 5.6 ml/kg/hr. to 0.8 (4 +5-1)ml/kg/hr., which is 6.4ml/kg/hr. So with this formula, the AIIMS-ICU protocol is being proven to be similar to that of Sheffield. Without this Formula it looked as if these two institutions were using dissimilar protocols.

The above discussion has also indicated that this Formula can be useful for the calculation of maintenance fluid volumes in term babies, so far as they are weighing less than 4kg. Remember that for term babies the value of the rehydration factor should be lower (by a unit or two). That is, instead of using 5 as the rehydration factor, a lower value between 2 or 5, is used.

Again, there is an anticipated usefulness of this formula for research purposes; the specific and quotable value of R becoming instrumental to this. This is because a Center can quote by which value of R the research on maintenance fluid volume was conducted.

CONCLUSIONS

It is recommended that 'RAW' Formula, *20 (R+A-W)* ml kg?$^{-1}$ day?$^{-1}$ or 0.8(R+A-W) ml ?$^{-1}$ kg ?$^{-1}$ Hr?$^{-1}$, be used in Calculating Maintenance Fluid Volumes in Low Birth-Weight and Premature Babies. This is because its accuracy had been validated; having compared and noted that there is no statistically significant difference between the Table constructed from it with the original Table. Among other advantages, it was discovered that Advocates of different Fluid Regimens can use it.

It should, however, be understood that the guiding principles with regards to selection of intravenous fluid-type and administration of electrolytes to this category of babies are still the same as when the Tables are being used .

REFERENCES

1. Wilson CM. Sheffield children's Hospital, preoperative fluids In Children. Update in Anesthesia issue 19(2005). Article 14.Update19-2004. Available fromhttp://www.wfsahq.org/resources/update-in-anaesthesia?id=392.Accessed on 13th February 2015.
2. Oh T H. formulas for calculating fluid maintenance requirements. Anesthesiology.1980.53; 351.
3. Rachel S. Pediatric Fluid and Electrolyte TherapyJ PediatrPharmacolTher. 2009 Oct-Dec; 14(4): 204-211.Available from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3460795.Accessed on 15th February 2015
4. Hatch & Sumner's Textbook of PaediatricAnaesthesia Third edition.Edited by Robert Bingham, Adrian Lloyd Thomas,M Sury - 2007 Prescribing Intravenous Fluids In Children.?Available fromhttps://books.google.com/books?isbn=1444113836.Accessed on 19th February 2015.
5. Catharine Wilson. Anaesthesia UK Paediatricfluids.Self-assessment.Available from www.frca.co.uk/article.aspx?articleid=100481Accessed on 13th February2015.
6. Malcolm A Holliday, Patricio E Ray, and Aaron L FriedmanFluid therapy for children: facts, fashions and questions. Arch Dis Child. 2007 Jun; 92(6): 546-550.Available from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2066164.Accessed on 17th February2015.
7. Available from http://en.wikipedia.org/wiki/Preterm_birth. Accessed on 10th February2015.10/02/2015
8. World Health Organisation, Preterm birth fact sheet, Geneva WHO, 2012N°363 Updated November 2014.Available fromwww.who.in/mediacentre/facts sheet/fs363/en/Accessed on 10th February2015.
9. Blencowe H1, Cousens S, Oestergaard MZ, Chou D, Moller AB, Narwal R, et al. National, regional, and worldwide estimates of preterm birth rates in the year 2010 with time trends since 1990 for selected countries: a systematic analysis and implications. Lancet. 2012 Jun 9;379(9832):2162-72.Available from http://www.ncbi.nlm.nih.gov/pubmed/22682464.Accessed on 10th February2015.
10. Edward F Bell, Michael J. Acarregui. Fluid and electrolyte management in the newborn.Available fromhttp://www.uichildrens.org/childrens-content.aspx?id=233964.Accessed on 10th February2015.
11. Charles L Snyder.Fluid Management for the Pediatric Surgical Patient.Medscape.Updated: Mar 21, 2013.Available from http://emedicine.medscape.com/article/936511-overview.Accessed on 17th February2015.
12. J Bhatia Fluid and electrolyte management in the very low birth weight neonate. Journal of Perinatology (2006) 26, S19-S21.Available from http://www.nature.com/jp/journal/v26/n1s/full/7211466a.htmlAccessed on 10th February2015.
13. Modi, N. Management of fluid balance in the very premature neonate.Arch Dis Child Fetal Neonatal Ed. 2004; 89:108-111.
14. Bauer K, Versmold H Postnatal weight loss in preterm neonates less than 1,500g is due to isotonic dehydration of the extracellular volume. ActaPaediatrScand Suppl. 1989;360:37-42.
15. Bauer K, Versmold H, Prölss A, De Graaf SS, Meeuwsen-Van der Roest WP, Zijlstra WG. Estimation of extracellular volume in preterm infants less than 1500 g, children, and adults by sucrose dilution.Pediatr Res. 1990 Mar;27(3):256-259.
16. Isabeau Walker. Karen Wouters. Neonatal Anaesthesia 1: physiology.Created: 14/8/2007.Available

fromhttp://www.frca.co.uk/article.aspx?articleid=100980.Accessed on 17th February2015.

17. Melanie S.Kim, Michael JG Somers. Fluid and Electrolyte Physiology and Therapy in Oski'sPaediatrics: Principles and Practice 9: 55 edited by Julia A. McMillan, ?Ralph D. Feigin, ?Catherine DeAngelis.Available from https://books.google.com/books?isbn=0781738946Accessed on 17th February2015.
18. Cartlige, P. The epidermal barrier.SeminNeonatol 2000 Nov;5(4) 273-80. Available fromhttp://www.ncbi.nlm.nih.gov/pubmed/11032710.Accessed on 10th February2015.
19. Modi, N. Management of fluid balance in the very premature neonate SeminNeonatol 2000; 5: 273-280.Available fromhttp://www.cardiffandvaleuhb.wales.nhs.uk/opendoc/191785.Accessed on 10th February2015.
20. Bell EF, Acarregui MJ, Restricted versus liberal water intake for preventing morbidity in preterm infants. Cochrane Database Syst. Rev 2000; 2:CD000503..
21. Learn math's step-by-step.BODMAS Rule. Available from www.math-only-math.com/bodmas-rule.htm Accessed on 17th February2015.
22. Math is fun equation.Available fromhttps://www.mathsisfun.com/definitions/equation.htmAccessed on 17th February2015.
23. Available from http://en.wikipedia.org/wiki/Formula.Accessed on 10th February2015.
24. Deepak Chawla, Ramesh Agarwal, Ashok K. Deorari and Vinod K. Paul.Fluid and electrolyte management in term and preterm neonates.AIIMS-ICU Protocols. The Indian Journal of Pediatrics. March 2008, 75; 3:255-9.Available from www.newbornwhocc.org http://www.slideshare.net/nnbrishti/fluid-electrolytes-bablance150308.Accessed on 15th February2015.