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The making of a ruler for everyday pediatric drug prescription in a field trauma hospital

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ABSTRACT

Traumatic brain injury (TBI) is a worldwide major cause of morbidity and mortality particularly in the vulnerable population young males, low-income individuals and members of ethnic minority groups.

Severe TBI, defined as head trauma associated with a Glasgow Coma Scale (GCS) score of three to eight with loss of consciousness duration and altered mental status greater than 24 hours and post traumatic amnesia more than seven days.

In this resume of protocols article, a helpful review of the current status of management of severe TBI according to the recent up-dated brain trauma foundation 2016 and the National Institute for Health and Care Excellence (NICE) 2014 guidelines is present. A concise overview of the optimal medical management, and both the non-invasive and invasive monitoring strategies, as well as the indications of surgical interventions necessary in particular instances. It is important not only for trauma team but for all healthcare personnel to be aware of the management and prevention of complications of severe traumatic brain injury.

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INTRODUCTION

In the spring of 2017, during the final assault on Islamic State of Iraq and Syria (ISIS) in Mosul, Iraq, in the neighborhood of the city was set up a World Health Organization (WHO) type two "plus" field hospital, similar to North Atlantic Treaty Organization (NATO) role two call '+' (role 2+) facility, meant to provide short-term surgical and medical support to civilian and military victims of the fighting. A role two support, is an intermediary field medical facility prepared to provide evacuation from role one facilities, triage, resuscitation, treatment and holding of patients until they can be returned to duty or evacuated. When the capabilities to perform emergency surgery and essential post-operative management are present, it is often referred to as role 2+ [1].

Purpose built semi-permanent premisesharbored 40 trauma beds and 20 independent maternity beds. It was managed jointly by an international medical company and the local Ministry of Health that provided about two thirds of the personnel. Rapidly arose the problem of the prescription of drugs at appropriate posology to children. Almost all doctors and surgeons, Iraqis and internationals, were practitioners with no specific training in pediatrics but were in charge of numerous children in the emergency room (ER) and in the wards. The pediatric population represented roughly 50% of the patients [2]. The weight of children was guessed, often because the traumatic lesions they suffered from, mainly due to explosions and small arms fire, did not allow weighting them. The consequences were frequent inappropriate dosage of antibiotics, painkillers and other commonly used drugs, and a variation of doses with the change of the prescriber. A practical, affordable, easy to implement, solution had to be found in order to standardize pediatric drug prescription according to international standards and good practice.

REPORT

The seek for a solution

No structured working group was set-up. An emergency doctor and an anesthesiologist, with the collaboration of other practitioners, decided to tackle the problem. Commonly used formulas and tables were considered. All formulas and tables based on weight were discarded because of the great difficulty encountered in weighting traumatized children with war injuries on bathroom type scales, the only ones available. Age was not always available or reliable, furthermore the formulas using age needed calculations, and calculations were considered a possible source of errors. Body surface area was not considered as appropriate, considering that its calculation needs the use of the nomogram plus length and weight. In the ER, patients commonly arrived in a context of mass casualty, and in such conditions the risk for calculation errorsis increased. In the wards there was no specific attribution of patients to surgeons and doctors, therefore prescribers could vary from day to day, or even from shift to shift. Doctors used different formulas and often simply divided the adult dose in order to proportionally adapt it to the supposed weight of the child. Furthermore, resistance to change was felt as being strong.

In this context, a new and simple tool not implying calculations or patient's particular mobilization was considered as appropriate and possibly acceptable for the staff.

A tool used to identify pediatric emergency drug dosage and equipment size, not implying calculations or body weight, was in possession of one of the international staff: the emergency tape developed by Biarent D. of the pediatric intensive care and emergency department (ED) of the Hôpital Universitaire des Enfants in Brussels, Belgium.

This is a 150 per 10 cm plastic tape, graduated kg per kg for weights from 3 to 34 kg corresponding to lengths from 50 to 150 cm, cm per cm. Every 4 to 5 cm can be found a color change. To each color corresponds a table indicating the doses for emergency drugs such as adrenalin, amiodarone, etomidate, ketamine, rucuronium and morphine. On the back, larger color zones show the required defibrillation energy and the size of reanimation devices like Guedel and tracheal tubes, nasogastric tube, etc. [3] (**Figure 1**). This tape is based on the same principle of the Broselow tape that is to say on the relationship between weight and length across all ages. It was decided to create a tool based on the principle of the Biarent's tape described above, with the means available on the spot. The choice of Biarent's tape as a reference was dictated by three considerations: the great difficulty in purchasing other similar tapes, such as the more widespread Broselow tape, the need for a quick solution, and the absolute need, for educational reasons, of a tangible specimen of the reference tool. The new tool had to be used in the emergency room and in the wards.

The making of the ruler

Being impossible to make locally a tape in a material that could be disinfected, it was chosen to make a ruler instead, using a plastic board initially conceived as a curtain rail. It was decided that the ruler had to be dedicated to drugs, thus excluding equipment. A list of drugs was established following a number of principles. The drugs had to be:

- related to the main problems of the children: pain, anxiety, infection;
- commonly used by the surgeons and doctors;
- available in the hospital's pharmacy;
- not related to resuscitation.

Concerning the last point it was felt that resuscitation drugs had to be reserved to experts having sufficient knowledge, training and experience in this field. An exception was made for adrenalin, in consideration of the fact that in case of a cardiac arrest the first responder could be a doctor untrained in pediatric resuscitation. Doses per weight tables were made. Accepted formulas were used to calculate the posology of the different drugs according to weight [4;5]. It immediately appeared that, considering the relatively big number of drugs to be included, the ruler would not allow tables per each kg of weight. In order to keep the ruler readable at a glimpse, it was decided to calculate the drug doses only at specific lengths/weights: 3, 6, 10, 15, 20, 30 kg and to insert only the tables corresponding to these length marks. For each of these marks, clearly identified by a different color, the length chosen was the one corresponding to the mean length of the corresponding interval of the Biarent's tape. Furthermore, dosages have been voluntarily calculated within the safe zone in order to give a sufficient tolerance to weight variations. When a dose interval was given, the mean value was used to calculate the dose. It was considered that the children whose weight would fall in between two of the calculated doses could benefit of an "in-between" dose calculated by the prescriber. In order to facilitate precise calculations of drug doses, if wanted and possible, every name of a drug was followed by the per kg dose and for every drug the frequency of administration was clearly stated. Each table consisted of two graphically different parts: the first one dedicated to miscellaneous drugs and the second dedicated to antibiotics. The tables and their content can be seen in **Figure 1**.

A common spreadsheet was used to create and print a metric scale and the drug dose tables. The scale indicating the estimated weights was glued along the board's edge. On the same side, were glued the tables corresponding to the chosen weights. The first 50 cm of the ruler, corresponding to the length of a 3 kg newborn, were used to glue tables indicating the children vitals, fluids needs and transfusion volumes according to weight. Both surfaces were covered with transparent plastic sheets fixed on the back with plastic tape in order to allow disinfection (**Figures 1 to 3**).

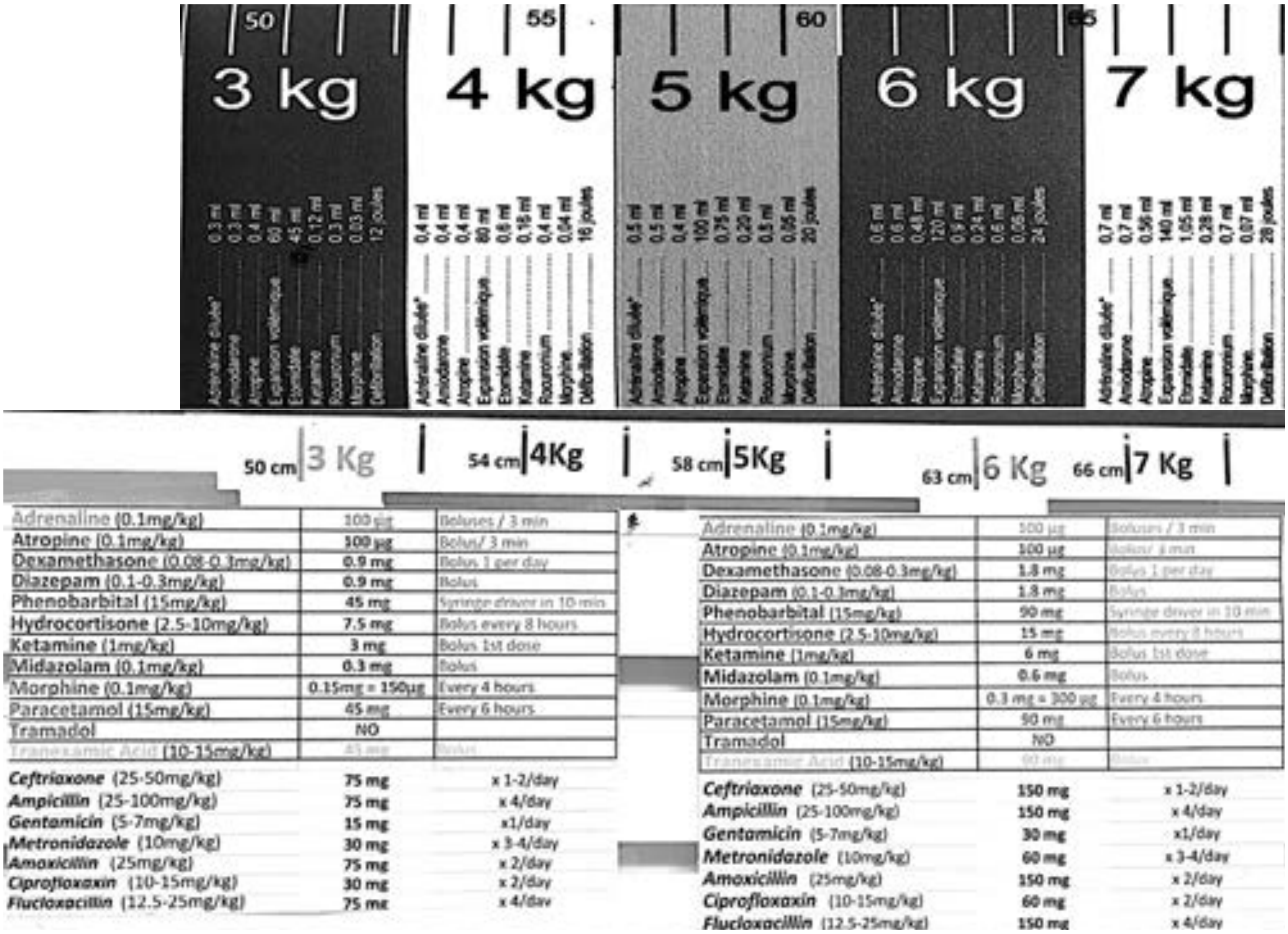

Figure 1: A section of Prof. Biarent's tape for pediatric resuscitation on the side dedicated to drugs and the corresponding section of the children's drug ruler with the drug tables.

Figure 2: The first 50 cm of the children's drug ruler with the measurement starting point and the tables indicating vitals, fluids needs and transfusion volumes according to weight.

The introduction and use of the ruler

Once made, the ruler was presented during dedicated meetings held with doctors and nurses. During these meetings were justified the need for improvement in children's drug prescription as a global and local issue, the ruler's genesis and use. Carton shapes of children were used for demonstration and initial training. Common mistakes, such as the incorrect positioning of the child during measurement, were put forward. During the days following the presentations, the ruler was left available at all times in the ER and the promoters of its use would, during normal work activity, gently remind its existence to the fellow practitioners. Fifteen days later the ruler was regularly used in the ER and started to be part of common practice in the wards. Younger doctors were the first ones to use it regularly. Unfortunately, due to rapid personnel turnover and the global emergency conditions, no structured survey and follow up could be made. Informal feedback suggested that the ruler was

50 cm	3 Kg	
Adrenaline (0.1mg/kg)	100 μg	Boluses / 3 min
Atropine (0.1mg/kg)	100 μg	Bolus/ 3 min
Dexamethasone (0.08-0.3mg/kg)	0.9 mg	Bolus 1 per day
Diazepam (0.1-0.3mg/kg)	0.9 mg	Bolus
Phenobarbital (15mg/kg)	45 mg	Syringe driver in 10 min
Hydrocortisone (2.5-10mg/kg)	7.5 mg	Bolus every 8 hours
Ketamine (1mg/kg)	3 mg	Bolus 1st dose
Midazolam (0.1mg/kg)	0.3 mg	Bolus
Morphine (0.1mg/kg)	0.15mg = 150μg	Every 4 hours
Paracetamol (15mg/kg)	45 mg	Every 6 hours
Tramadol	NO	
Tranexamic Acid (10-15mg/kg)	45 mg	Bolus
Ceftriaxone (25-50mg/kg)	**75 mg**	x 1-2/day
Ampicillin (25-100mg/kg)	**75 mg**	x 4/day
Gentamicin (5-7mg/kg)	**15 mg**	x1/day
Metronidazole (10mg/kg)	**30 mg**	x 3-4/day
Amoxicillin (25mg/kg)	**75 mg**	x 2/day
Ciprofloxaxin (10-15mg/kg)	**30 mg**	x 2/day
Flucloxacillin (12.5-25mg/kg)	**75 mg**	x 4/day

63 cm	6 Kg	
Adrenaline (0.1mg/kg)	100 μg	Boluses / 3 min
Atropine (0.1mg/kg)	100 μg	Bolus/ 3 min
Dexamethasone (0.08-0.3mg/kg)	1.8 mg	Bolus 1 per day
Diazepam (0.1-0.3mg/kg)	1.8 mg	Bolus
Phenobarbital (15mg/kg)	90 mg	Syringe driver in 10 min
Hydrocortisone (2.5-10mg/kg)	15 mg	Bolus every 8 hours
Ketamine (1mg/kg)	6 mg	Bolus 1st dose
Midazolam (0.1mg/kg)	0.6 mg	Bolus
Morphine (0.1mg/kg)	0.3 mg = 300 μg	Every 4 hours
Paracetamol (15mg/kg)	90 mg	Every 6 hours
Tramadol	NO	
Tranexamic Acid (10-15mg/kg)	90 mg	Bolus
Ceftriaxone (25-50mg/kg)	**150 mg**	x 1-2/day
Ampicillin (25-100mg/kg)	**150 mg**	x 4/day
Gentamicin (5-7mg/kg)	**30 mg**	x1/day
Metronidazole (10mg/kg)	**60 mg**	x 3-4/day
Amoxicillin (25mg/kg)	**150 mg**	x 2/day
Ciprofloxaxin (10-15mg/kg)	**60 mg**	x 2/day
Flucloxacillin (12.5-25mg/kg)	**150 mg**	x 4/day

Figure 3: Examples of the drug tables with corresponding weights as glued on the children's drug ruler.

perceived as easy and practical to use, and that the number of practitioners using it was increasing in time.

DISCUSSION

The inappropriate dosage of drugs in children is a common malpractice all over the world [6-8]. The WHO considers the safe use of medications in children of paramount importance, but its implementation faces numerous difficulties [9]. In settings where changes have to be operated swiftly and environmental conditions do offer neither time nor serenity to conduct appropriate trainings to modify customs, alternative solutions allowing the enforcement of good practices have to be found. The ruler presented in this article, based on the weight per length relationship, is one of these alternatives. The use of rulers for pediatric drug description is not new, although it has mainly been focused on emergency, life saving, drugs and pre hospital settings [8]. Many forms of colour-coded paediatric dosing rulers exist, but two are the particularities of this experience that may be pointed out. First the use of the ruler not for emergency drugs in pre hospital settings but for every day drugs such as painkillers and antibiotics for in-patients, thus extending the use of the concept, and, secondly, the fact of being self-made with cheap and widespread means, which allows independence from market constraints. This ruler is based on the weight per length relationship but weight per length may be affected by acute malnutrition and obesity and consequently the accuracy of the ruler may be affected. Despite that, the available studies, centered on the Broselow's and not on Biarent's tape, although critical, do not put forward sufficient evidence to formally discourage its use [10-12]. Although no nutritional survey was conducted, apart from some clearly malnourished children, the vast majority of the children seemed in normal nutritional conditions. Dehydration, another possible bias, was considered of minor importance since its correction would usually precede the prescription of other drugs. Recommendations were made about taking these parameters into consideration and, if considered necessary, to proceed calculating the doses according to the formula appearing in the table close to the drug's name. The use of the length-weight-dose correspondence was therefore considered applicable in this specific work environment in consideration of the local benefit-risk ratio.

CONCLUSIONS

The inappropriate dosage of drugs in children is a common medical malpractice. The use of a tool like the "Children's drug ruler" may be a solution, especially in difficult environments where resources and time are scarce for the implementation of behavioral change. It is a very flexible tool. It can be used for a variety of drugs, adapting it to the content of local pharmacies, and it can be used for oral or intravenous drugs. It can be a prescription support for doctors and nurses alike and be used as a tool to promote the safe prescription of drugs to children in environments with scarce resources or poorly trained personnel. Its main drawback is represented by a high prevalence of malnutrition. It can easily be made at a very low cost. This makes it very adapted to situations in which financial resources are scarce.

Appropriate testing on a longer period in a more serene context would be appropriate to fully establish its usefulness and safety. This experience shows how, with some creativity, simple and useful, if not radically new, tools can be easily made with very limited resources and can rapidly be accepted and used in a variety of contexts. But it also contributes to raise a question. Safe drug prescription to children is a recognized worldwide priority, numerous experiences show that rulers and similar tools may be extremely useful in reducing malpractice: why are rulers not more rife in medical practice?

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