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Research Article

# Fluid resuscitation protocols for burn patients at intensive care units of the United Kingdom and Ireland

# Programme für den Flüssigkeitsersatz bei Patienten mit Verbrennungen der Haut auf den Intensiveinheiten des Vereinigten Königreichs und Irlands

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## Abstract

**Introduction:** The objective of this study was to determine the thermal injury fluid resuscitation protocols at intensive care units (ICUs) in the United Kingdom and Ireland.

**Materials and methods:** A telephone questionnaire was designed to survey the fluid resuscitation protocols of ICUs at all hospitals with plastic/burn surgery departments in the British Isles in 2010. The feedback from the questionnaire was from the senior nurse in charge of the ICUs.

**Results:** 32/64 (50%) of these ICUs had provided care to burns patients. A 100% response from these 32 units was obtained. 71.4% commence fluid resuscitation at 15% total body surface area burn (TBSA), 21.4% at 20% TBSA and 7.1% at 10% TBSA in adults. The estimated resuscitation volume was most often calculated using the Parkland/Modified Parkland formula (87.5%) or the Muir and Barclay formula (12.5%). Interestingly, of the ICUs using formulae, two had recently moved from using the Muir and Barclay formula to Parkland formula and one had recently moved from using the Parkland formula to Muir and Barclay formula. Despite this, 37.5% of ICUs using a formula did not rigidly follow it exactly. The most commonly used resuscitation fluid was Ringer's lactate solution (46.9%) and Human Albumin Solution was used in 12.5%. No ICU used red cell concentrate as a first line fluid. 18.8% used a central line. 40.6% ICUs considered changing the IV solution during resuscitation. 78.1% ICUs consider urine output to be the most important factor in modifying resuscitation volumes. 59.4% ICUs calculate a maintenance fluid rate after completion of resuscitation. The endpoint for resuscitation was at 24 h in 46.9% ICUs and at 36 h in 9.4%. 5/32 (16%) felt their protocol gave too little and 6/32 (19%) felt their protocol gave too much. 59.3% ICUs gave oral/enteral fluids by naso-gastric or naso-jejenal tubes. 21.9% felt that oral/enteral resuscitation worked. Exactly half of the units believed that the formula that they used provided approximately the right amount of fluid, with 25% believing that it provided too much and 21.9% that it provided too little.

**Discussion and conclusion**: There is substantial variation in the fluid resuscitation protocols for burns of ICUs in the British Isles. The different practices demonstrated in this survey may have important consequences as inadequate fluid resuscitation can limit perfusion to potentially recoverable burns, grafted tissue and body organs not directly injured.

**Keywords:** burns, fluid resuscitation, colloids, crystalloids

## Zusammenfassung

**Einleitung:** Ziel der Studie war es, Programme für den Flüssigkeitsersatz bei Patienten mit Verbrennungen auf den Intensiveinheiten in England und Irland zu entwickeln.

**Material und Methoden**: Im Jahre 2010 wurden die Programme für den Flüssigkeitsersatz nach Verbrennungen auf den Intensiveinheiten durch Telefonumfragen abgefragt. Eingeschlossen waren die Intensiveinheiten der plastischen Chirurgie und die Abteilungen für Verbrennungen auf den britischen Inseln. Die Rückantwort kam von der leitenden Pflegekraft im Auftrag der jeweiligen Intensiveinheit.

**Ergebnisse:** 32 von 64 Intensiveinheiten (50%) versorgten Patienten mit Verbrennungen. Von diesen 32 Intensiveinheiten lagen Antworten vor. Bei Erwachsenen beginnen 71,4% mit Volumenersatz ab 15% der verbrannten Körperoberfläche (TBSA), 21,4% bei 20% der TBSA und 7,1% bei 10% TBSA. Das errechnete Ersatzvolumen wurde am häufigsten mit Hilfe der „Parkland/Modified-Parkland“ Infusionsformel (87,5%), oder der Muir und Barclay-Formel (12,5%) errechnet. Von den Intensiveinheiten wechselten 2 von der Muir und Barclay-Formel zu der Parkland-Formel und eine Einheit wechselte kürzlich von der Parkland-Formel zu der Muir- und Barclay-Formel. Unabhängig davon folgten 37,5% der Intensiveinheiten nicht den vorgegebenen Infusionskonzepten.

Die am häufigsten verwendete Ersatzflüssigkeit war Ringer-Laktat-Lösung (46,9%) und Humanalbumin-Lösung (12,5%). Keine Intensiveinheit verwendete Erythrozyten-Konzentrate als ersten Flüssigkeitsersatz. 18,8% verwendeten einen zentralen Zugang. 40,6% der Intensiveinheiten überlegten die intravenöse Flüssigkeitszufuhr zu ändern.

78,1 der Intensiveinheiten betrachten die Harnausscheidung als wichtigste Größe bei der Anpassung des Infusionsvolumens. 59,4% der Intensiveinheiten errechnen die Flüssigkeitszufuhrrate nach Erreichen des Flüssigkeitsausgleiches. Der Endpunkt des Flüssigkeitsausgleiches war nach 24 Stunden in 46,9% der Intensiveinheiten, nach 36 Stunden in 9,4% erreicht. 5 von 32 (16%) Intensiveinheiten waren der Meinung, dass ihr Konzept zu wenig, und 6 von 32 (19%), dass es zuviel Flüssigkeit zugeführt habe. 59,3% der Intensiveinheit verabreichten oral/enteral Flüssigkeit durch Nasen- und Magensonden oder durch Nasen-Jejunal-Sonden. 21,9% sind der Meinung, dass oraler/enteraler Flüssigkeitsersatz ausreichend ist. 50% der Einheiten glauben, dass das Infusionsprogramm, das sie verwendet haben, ungefähr die richtige Menge von Flüssigkeit zuführt, 25% glaubten, sie hätten zuviel, und 21,9%, sie hätten zu wenig Flüssigkeit zugeführt.

**Diskussion und Schlussfolgerung:** Auf den Britischen Inseln gibt es eine große Variation in Programmen des Flüssigkeitsersatzes bei Patienten nach Verbrennungen. In der Studie wird darauf hingewiesen, dass unterschiedliche Vorgehensweisen wichtige Konsequenzen haben können, da inadäquater Flüssigkeitsersatz Perfusion von geschädigtem Gewebe, transplantiertem Gewebe und von Organen, die nicht direkt geschädigt waren, vermindert.

**Schlüsselwörter:** Verbrennungen, Flüssigkeitsersatz, kolloidale und kristalline Lösungen

## Introduction

The burned patient is at risk of hypovolaemia, which may progress to organ failure, and even death. A major goal of the initial management of burn injuries is to replace extracellular fluid loss proportional to percent total body surface area (% TBSA) of the burn [1], [2]. Fluid resuscitation has been acknowledged as an intervention that has contributed to reductions in these complications [1], [2]. The regimens used in fluid resuscitation have evolved over years, though it is accepted that the evidence base guiding formula selection remains weak. Studies have examined variation in the choice of regimens between burns units through postal questionnaires [3], [4], [5], [6].

Although the importance of satisfactory volume replacement in burn patients is generally accepted, the optimal strategy is still a focus of debate [1], [3], [4], [5], [6], [7]. Different formulae varying with the amount and type of fluid exist – timing and monitoring of fluid therapy are also controversial issues. The Muir & Barclay formula was popular in the United Kingdom since 1962 [8]. The origin-

**Table 1: Comparison of Muir and Barclay and Parkland formulas for burns resuscitation**

| Parkland | Muir and Barclay |
|---|---|
| Crystalloid resuscitation with Ringer's lactate | Colloid resuscitation with plasma |
| 24 hour fluid requirement = 4 x %BSA x Wt (Kg) | The first 36 hours are divided into time periods of 4,4,4,6,6,12 hour intervals |
| Give half over the first 8 hours, and the remainder over the next 16 hours | Each interval = 0.5 x %BSA x Wt (Kg) |

al formula used freeze-dried plasma plus sufficient 5% dextrose solution to satisfy the metabolic water requirement. In the late 1980s Human Albumin Solution 4.5% replaced plasma solutions as the resuscitation fluid. In 1968, Baxter and Shires developed a formula without colloid, which is now referred to as the Parkland formula [9]. It advocated an administration of 4 ml of Ringer's lactate/kg/% burn during the first 24 hours – half of this being given in the first eight hours and the other half in the subsequent 16 hours after the burn (Table 1).

The aim of this survey was to describe the actual practise of fluid resuscitation in the burn patient in the United Kingdom and Ireland in 2010.

## Methods

A telephone questionnaire was designed to obtain regarding fluid resuscitation protocols. This included details regarding the level of burns facility, the protocol used for intravenous fluid resuscitation, fluid monitoring techniques, the preferred access route and the use of enteral fluids as part of resuscitation.

All 64 hospitals with a plastic surgery and/or burns department listed by the British Association of Plastic, Reconstructive and Aesthetic Surgeons in the United Kingdom and Ireland were contacted by telephone. The questionnaire was posed to the senior nurse involved in delivering burns care, if the plastic surgery unit was in a hospital that had provided any critical care level burns care in 2010. The feedback from the questionnaire was from the senior nurse in charge of the ICUs.

## Results

All 64 plastic surgery units were contacted. 32 of the 64 (50%) were in centres that had provided critical care level burns care in 2010. The response rate was 100%.

Of the 32 centres, 43.8% provided care to adults only, 15.6% to children only and 40.6% to adults and children.Of those 14 centres that had provided adult-only care, 71.4% commenced fluid resuscitation at 15% total burned surface area (TBSA). Of the remainder, 21.4% commenced resuscitation at 20% TBSA and 7.1% at 10% TBSA. Paediatric-only centres all commenced fluid resuscitation at 10% TBSA. Of the 13 units that had treated both adults and children, the majority (84.6%) commenced resuscitation at 15% TBSA for adults and 10% TBSA for children, whilst the minority (15.4%) commenced resuscitation at 15% for all cases (Figure 1 and Figure 2).

81.3% departments preferred to use peripheral access for resuscitation, whilst 6.3% preferred central access, and 12.5% used a combination of central and peripheral access without specific preference.

81.3% centres followed the Parkland formula, and a further 6.3% centres used a modified Parkland formula. 12.5% centres used the Muir and Barclay formula (Figure 3). All paediatric-only units used the Parkland formula or modifications of it. Of the 32 centres, two had recently changed from the Muir and Barclay formula to the Parkland formula, and a further centre had changed from the Parkland to the Muir and Barclay formula. In keeping with this, lactated Ringer's solution (LR) was the initial intravenous fluid used by Parkland formula centres in all bar one case, where 0.9% saline was the preferred initial fluid. All Muir and Barclay formula centres used 4.5% human albumin solution (HAS) as their initial fluid. However, over one third of centres (37.5%) do not follow their protocol exactly.

The most commonly used resuscitation fluid was Ringer's lactate solution in 46.9%; Human Albumin Solution was used in 12.5%. No ICU used red cell concentrate as a first line fluid. 18.8% used a central line to measure right ventricular preload. 34.4% ICUs considered changing the IV solution during resuscitation. 78.1% ICUs consider urine output to be the most important factor in modifying resuscitation volumes. 59.4% ICUs calculate a maintenance fluid rate after completion of resuscitation. The endpoint for resuscitation was at 24 h in 46.9% ICUs and at 36 h in 8.3%.

40.6% centres frequently consider changing the intravenous fluid during the resuscitation period. Of these thirteen units, two change from HAS to a LR during resuscitation, two change from LR to HAS, one changes from LR to 0.9% NaCl and four units use colloid boluses in addition to crystalloid-based formulae. The remaining four units alter fluids on a case-by case basis (Figure 4).

Centres use a variety of measurements to guide adjustments to fluid resuscitation rates, and frequently use combinations of measurements. 84.4% ICUs consider urine output to be the most important factor in modifying resuscitation volumes. Although most ICUs adjust the fluid rate based on the urine output, and often use invasive monitoring to adjust rates,12.5% centres use blood results in addition to these factors. 46.9% centres complete resuscitation at 24 hours post burn, with 9.4%

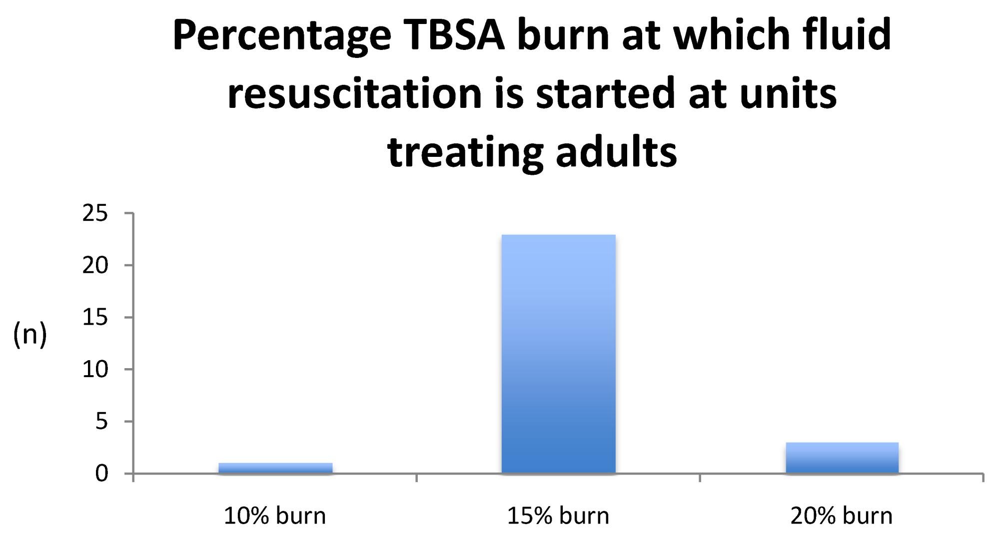


Figure 1: Percentage TBSA burn at which resuscitation started in units treating adults

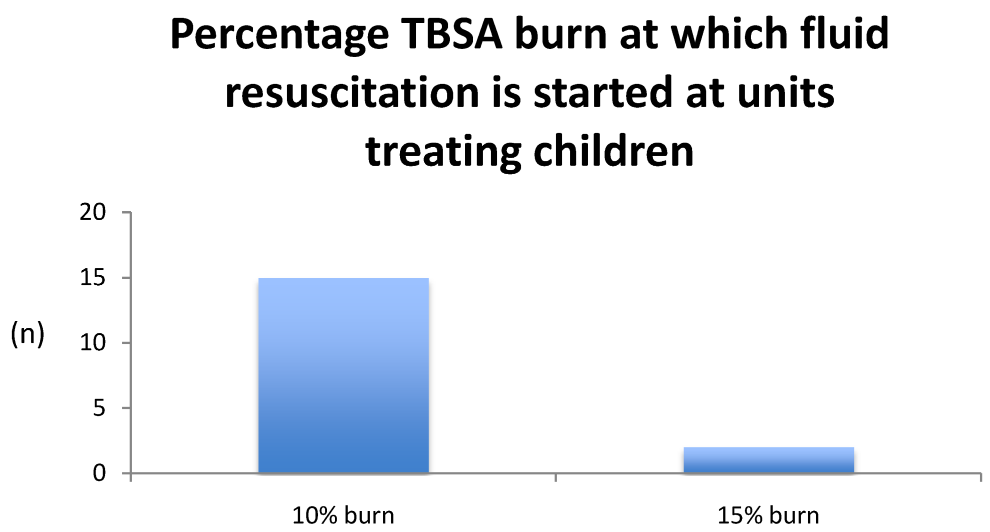


Figure 2: Percentage TBSA burn at which resuscitation started in units treating children

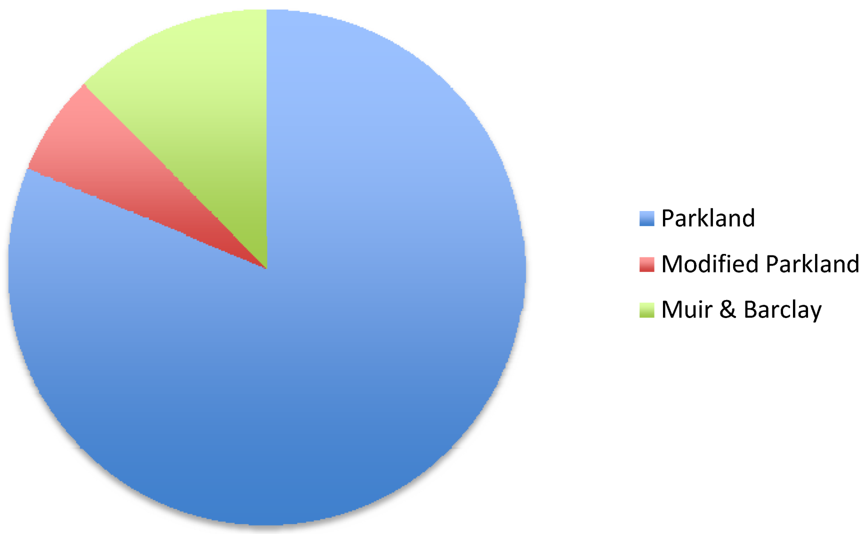


Figure 3: Fluid resuscitation formulae used by different units

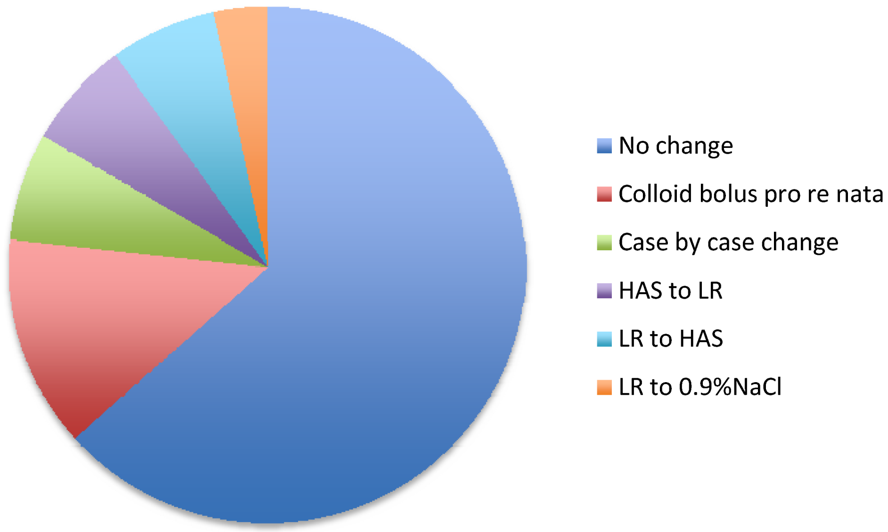


**Figure 4: Fluid changes routinely considered during resuscitation period (HAS – 4.5% human albumin solution, LR – lactated Ringer's solution, NaCl – 0.9% sodium chloride solution)**

completing at 36 hours and 6.3% at 48 hours. Other units end resuscitation based on the patient's condition and vital signs. 56.3% units use a formula to calculate maintenance fluids after completing resuscitation.

90.6% of those questioned were subjectively happy with their resuscitation protocol, though variation from the formula was acknowledged. Exactly half of the units believed that the formula that they used provided approximately the right amount of fluid, with 25% believing that it provided too much and 21.9% that it provided too little. Only one of those questioned was dissatisfied, subjectively believing that their Parkland-based protocol routinely underfilled patients.

Most hospitals (84.4%) gave fluids (in particular feed) orally or enterally to burns patients, yet only 18.8% calculated an oral/enteral fluid volume as part of resuscitation. The majority of units (59.3%) that gave oral or enteral fluids used nasogastric tubes to administer fluid, with the remainder (40.7%) using nasojejunal or nasoduodenal tubes. The fluids used varied between water and various enteral feeds, which were often controlled by dieticians rather than medical or nursing staff. Only 21.9% of those questioned subjectively believed that oral/enteral fluids were an effective component of fluid resuscitation.

## Discussion and conclusion

This is the first paper to survey of fluid resuscitation protocols burns at all the intensive care units of the United Kingdom and Ireland. Effective fluid resuscitation is one of the cornerstones of modern burn care. Under-resuscitation can limit perfusion to potentially recoverable burns, grafted tissue and body organs not directly injured. Although since the adoption of weight and injury-size based formulas for resuscitation, multiple organ dysfunction and death caused by inadequate resuscitation has become uncommon [10]. The consequences of excessive resuscitation and fluid overload are as deleterious as those of under-resuscitation: pulmonary oedema, myocardial oedema, conversion of superficial into deep burns, elevated compartment pressures (with the need for fasciotomies in unburned limbs and abdominal compartment syndrome), acute respiratory distress syndrome, and multiple organ dysfunction [11].

In the UK, burns fluid resuscitation practice has undergone considerable change over the last decade. Changes in the protocols for burn resuscitation have been documented from predominantly colloid-based resuscitation in the early part of the last decade to crystalloid-based resuscitation more recently [1], [3], [4]. This suggested that burn unit practice in the UK and Ireland is moving into line with that used in the United States [4]. In 1997, a questionnaire study demonstrated that the majority of centres utilised the albumin-based Muir & Barclay regime [12] contrary to guidelines promoted during Advanced Trauma Life Support (ATLAS) and Emergency Management of Severe Burns courses that favoured the crystalloid-based Parkland Formula. In 1998, the Cochrane Injuries Group report questioned the appropriateness of using albumin in critically ill patients, particularly those with burn injuries [13]. In 2001, a similar questionnaire demonstrated that over 50% of centres managing paediatric burns continued to use the Muir and Barclay formula [4], but by 2007 most had changed to the Parkland formula [3]. This shift may have been influenced by national guidelines, the growing influence of ATLS, and by negative publicity surrounding the use of albumin resulting from Cochrane reviews [3], [12], [13], [14]. There may also be other theoretical reasons why colloid has decreased in popularity, such as its possible contribution to pulmonary oedema following resuscitation [1], [15].

Given this relatively recent change in practice, we aimed to establish whether this trend towards crystalloid had continued, and also to gather further data describing practice in the UK and Ireland. The telephone questionnaire ensured that the identity of the member of staff responding was clear, and by targeting senior nursing staff administering burn care, this data gives an accurate impression of exactly what resuscitation is administered to burns patients.

In keeping with previous findings, 15% TBSA was the commonest starting point for adult resuscitation, and 10% TBSA for children, though this was less consistent than previously documented. The Parkland formula again predominated, with 81% of hospitals using it. This figure is similar to the 78% of burns units using the Parkland formula, previously reported by Baker et al. [3] This suggests that the trend towards crystalloid resuscitation has been maintained. However, it was interesting to note that hospitals had recently switched between formulae in both directions, not just from Muir and Barclay to Parkland. The fact that these formulae only guide resuscitation is clear from the substantial proportion of hospitals (over a third) that routinely stray from the calculation and from the large proportion using at least urine output, if not invasive monitoring, to guide volume adjustments. Whilst it is appreciated that both under and over resuscitation are detrimental, urine output as a measure of resuscitation may not provide sensitive or specific monitoring and may not necessarily achieve the best prevention of organ dysfunction either [1], [16], [17], [18].

There are no level I or II publications to guide the choice of resuscitation fluid in the burned patient [14], [19], [20]. Two principles are essential, first that the least amount of fluid necessary to maintain adequate organ perfusion should be given, and second, that the volume infused should be continually titrated to avoid both under- and over-resuscitation [21]. Initial fluid choice followed the choice of formula in general. The only colloid used throughout was albumin, in comparison to German data, where starches have grown in popularity [22]. A rationale for switching resuscitation fluids, to attempt to minimise oedema by introducing a colloid once capillary permeability starts to improve is not a new concept [23]. However, our data found that only 40% of hospitals routinely change fluids during resuscitation. This is fewer than previously reported, and interestingly, equal numbers switch from crystalloid to colloid, as supported by this rationale, as switch from colloid to crystalloid.

Traditional dogma suggests that titration of fluids to maintain renal perfusion to obtain a urinary output of 30–50 ml/hr is considered adequate for adults [9], [10], [13]. Other physiological signs should be regularly assessed and recorded including heart rate, blood pressure, respiratory rate in addition to other signs of end-organ perfusion such as capillary refill time, core-peripheral temperature gap and conscious level. Blood tests such as acid-base balance, lactate and haemoatocrit may give further useful information. ICUs have sophisticated monitoring devices with variable invasiveness, leading some to suggest that resuscitation volumes can be targeted towards normalising cardiac pre-load. Studies on adults and children have failed to confirm the benefits of additional fluid administered in this pre-load driven approach with invasive hemodynamic monitoring [24], [25].

Approaches to oral and enteral resuscitation provided a range of responses. Whilst most hospitals provided enteral feeding for burns, only a minority routinely used oral or enteral fluids as a formal component of resuscitation. Furthermore, very few felt that it was effective. An international multicenter observational study studied nutrition practices in intensive care units and found that the mean time to start of enteral nutrition was 46.5 hrs [26]. There is relatively little modern literature describing the effect of these approaches to resuscitation, though Advanced Burn Life Support suggests that oral fluids may be used for small burns, and a study comparing oral administration of World Health Organization Oral Resuscitation Solution at Parkland formula rates to children with 10–20% burns found it to be as effective as the intravenous administration of the Parkland formula, suggesting that such scepticism may not be justified [27].

A major limitation of this study is that it does not describe outcomes for patients resuscitated differently. The design of it could not allow meaningful outcome data to be collected. When reviewing the literature comparing crystalloid and colloids for resuscitation, such as the Cochrane reviews mentioned earlier, it must be borne in mind that these reviews are not specific to burns, and thus will have limited applicability. Indeed, obtaining such outcome data for burns may not be a straightforward task. Endpoints such as mortality will be influenced by various confounding variables when treating burns patients, of which fluid resuscitation is just one, and also by case mix at hospitals with different levels of expertise. Even assessing adequacy of resuscitation depends on a correct, sensitive and specific parameter being measured and as discussed, common parameters such as urine output may not be the most appropriate. Despite this, variation such as ongoing changes from crystalloid to colloid and vice versa, as continues to occur, and a range of different approaches to changing fluids during the resuscitation period suggest that a consensus of expert opinion may be useful, especially for guiding hospitals that treat major burns relatively infrequently.

In conclusion, crystalloid resuscitation remains the most popular in the United Kingdom and Ireland. However, given the variation in practice demonstrated here, and the limitations of the evidence base underpinning fluid resuscitation, it is time to seek a consensus of expert opinion to guide fluid resuscitation.

# Notes

## Competing interests

The author declares that he has no competing interests.

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