Inpatient silver sulphadiazine versus outpatient nanocrystalline silver models of care for pediatric scald burns: A value analysis

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BACKGROUND/OBJECTIVE: Scalds represent the most frequent pediatric burn injury. Inpatient nonsurgical wound management of small or medium-size burns (<20% total body surface area) represents a significant proportion of the cost of care, with nanocrystalline silver (NCS) and silver sulphadiazine (SSD) among the most commonly used dressings. Although several articles have described healing outcomes using these dressings, there are few concurrent economic analyses. To analyze overall health care value (outcomes/cost) in burns not requiring surgery, the authors compared management of scald burns with NCS versus SSD from both a quality perspective and using bottom-up microcosting to determine which dressing option optimizes health care value.

METHODS: A value analysis was performed. Published studies investigating NCS and/or SSD in the treatment of pediatric burns over the past 25 years were analyzed. Healing time, hospital duration and frequency of dressings were chosen as quality metrics. A bottom-up microcosting analysis was performed to estimate costs associated with the two dressing options.

RESULTS: Over the 25-year period, 356 studies investigated the use of SSD in burns, while 55 studies evaluated the use of NCS. Mean age and burn size were equivalent. Mean time to healing was 14.9 days for NCS and 17.2 days for SSD. The mean duration of hospital stay was 14.9 days for SSD and 5.9 days for NCS. Dressings were performed twice per week for NCS, and once or twice per day for SSD. The mean total cost per patient to the health care system was estimated to be \$61,140 for SSD and \$17,220 for NCS.

CONCLUSION: Published outcomes of healing time are equivalent or slightly better using NCS over SSD for pediatric scalds. The financial model illustrated a potential significant cost saving with NCS, primarily as a result of an outpatient model of care. Overall health care value is optimized using NCS for pediatric scalds.

Key Words: Burn; Dressings; Microcosting; Pediatric; Scald; Value

Socialized health systems have little opportunity for increasing revenue streams and, therefore, must prioritize service offerings and new program funding (1). Whereas clinical care paradigms have evolved on an evidence-based philosophy, rarely is an evidence-based approach to resource allocation undertaken. In Canada, health care spending was estimated to be 11.6% of gross domestic product in 2012 and remains higher than many other developed countries (2,3). For such a significant expenditure, careful scrutiny of outcomes are paramount. Specifically, quality and safety metrics require careful evaluation because an increasing number of medical errors and prolonged delays to accessing the system produce inferior outcomes. A value model that has been championed by Michael Porter (4) encompasses these parameters in which value is defined as outcomes divided by cost.

Epidemiology

In the United States, approximately 250,000 children are burned every year, with 100,000 scalded by hot liquids or hot water immersion

Les modèles de soins à l'aide de sulfadiazine d'argent ou d'argent nanocristallin pour soigner des brûlures par ébouillantage en pédiatrie : une analyse de la valeur

HISTORIQUE ET OBJECTIF : L'ébouillantage est le principal type de brûlure en pédiatrie. La prise en charge non chirurgicale des plaies de petite à moyenne dimension (moins de 20 % de la surface corporelle totale) chez les patients hospitalisés représente une importante proportion du coût des soins, et parmi les pansements les plus utilisés, soulignons ceux recouverts d'argent nanocristallin (ANC) ou de sulfadiazine d'argent (SDA). Même si plusieurs articles ont porté sur les résultats de la cicatrisation à l'aide de ces pansements, peu d'analyses économiques simultanées ont été organisées. Pour analyser la valeur globale des soins (résultats et coûts) après des brûlures ne suscitant pas d'opération, les auteurs ont comparé la prise en charge des brûlures par ébouillantage à l'aide d'ANC et de SDA. Ils ont opté pour une perspective de qualité et un calcul des coûts sur une base individuelle pour déterminer le type de pansement qui optimise la valeur des soins.

MÉTHODOLOGIE : Les chercheurs ont effectué une analyse de valeur. Ils ont analysé les études publiées sur l'utilisation de l'ANC ou de la SDA pour traiter les brûlures pédiatriques depuis 25 ans. Le délai de cicatrisation, la durée d'hospitalisation et la fréquence des changements de pansements ont été retenus comme mesures de qualité. Ils ont effectué une analyse du calcul des coûts sur une base individuelle pour évaluer les coûts associés aux deux types de pansement.

RÉSULTATS : Pendant la période de 25 ans, 356 études ont porté sur l'utilisation de la SDA pour soigner les brûlures, tandis que 55 visaient à évaluer l'utilisation d'ANC. L'âge moyen et la dimension des brûlures étaient équivalents. Le délai moyen jusqu'à la cicatrisation était de 14,9 jours à l'aide de l'ANC et de 17,2 jour à l'aide de la SDA. La durée moyenne d'hospitalisation s'élevait à 14,9 jours avec la SDA et de 5,9 jours avec l'ANC. Les pansements étaient changés deux fois par semaine pour l'ANC, et une ou deux fois par jour pour la SDA. Le coût moyen total par patient pour le système de santé était évalué à 61 140 \$ pour la SDA et à 17 220 \$ pour l'ANC.

CONCLUSION : Les résultats publiés sur le délai de cicatrisation sont équivalents ou légèrement supérieurs à l'aide de l'ANC que de la SDA pour soigner des brûlures par ébouillantage en pédiatrie. Le modèle financier indique une possibilité d'économie marquée grâce à l'ANC, surtout au moyen d'un modèle de soins en milieu ambulatoire. La valeur globale des soins des brûlures par ébouillantage en pédiatrie est optimisée grâce à l'ANC.

(1). The American Burn Repository (2002 to 2012) has shown that hot liquids cause 33% of burn injuries, while hot surfaces only 9% (5). The age group with the highest incidence of scalds was in the 1 to 1.9 years of age group, and most burns (72%) were relatively small (<10% of total body surface area [TBSA]) (5).

There are no recent figures for Canada, but a study from a decade ago, investigating the demographics of pediatric burn injuries from 1994 to 2003 (2), reported that scald injuries represented 49% of 10,299 admissions. Most scald injuries tended to be relatively superficial (partial thickness to mid-dermal burns) and the prevalence of surgical procedures, such as burn wound excision and skin grafting, was low.

Dressing options

Traditional care for non-full-thickness burn wounds resulting from scalds in children consists of once- or twice-daily application of topical antimicrobial agents and, frequently, hospital admission, which is

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TABLE 1**Pooled demographics, burn size and outcomes for patients treated with silver sulphadiazine versus nanocrystalline silver**

Dressings used	Subjects, n	Age, years, mean	Mean burn wound, %TBSA	Hospital length of stay, days	Time to heal, days	Frequency of dressing change
Silver sulphadiazine	538	3.7	6.3	14.9	17.2	1.5 per day
Nanocrystalline silver	709	4.2	6.8	5.9	14.9	2 per week

*Data adapted from references 9-14. TBSA Total body surface area***TABLE 2****Total cost of care based on a bottom-up microcosting model for silver sulphadiazine (SSD) versus nanocrystalline silver (NCS) for the management of pediatric scald burns**

Dressing	Time to heal, days	Dressing frequency	Dressing care to heal, h	Cost/min dressing care, \$	Hospital length of stay, days	Total cost, \$			
						Per night in hospital	Hospital stay	Dressing care	Care per patient
SSD	17.2	1.5 per day	26	22	14.9	1,800	26,820	34,320	61,140
NCS	14.9	2 per week	5	22	5.9	1,800	10,620	6,600	17,220

costly and time consuming (6). In the pediatric population, larger scald burns can be a resource-intensive process and, historically, have been managed in an inpatient setting.

The ideal burn dressing should be easy to apply, cost effective, infrequently changed, nonpainful, allow easy burn assessment, manage exudate well, and have antimicrobial and wound protective properties (6). Silver sulfadiazine (SSD) cream (Flamazine, Smith & Nephew, USA), present on the market for the past four decades, has been the topical antimicrobial of choice at many burn centres. This drug has been used extensively worldwide as standard treatment for burn wound and often used in trials as a control. With new technological advances, a variety of burn dressings have flooded the market. One of the first nanocrystalline silver (NCS) dressings (Acticoat, Smith & Nephew, USA) has been present on the market for almost two decades and consists of two layers of nanocrystalline, silver-coated, high-density polyethylene mesh, enclosing a single layer of an apertured nonwoven fabric of rayon and polyester.

Cost

A question frequently raised worldwide during health policy debates is related to the financial sustainability of health care systems, when there are growing costs due to an aging population, new technological advancements and higher consumer expectations. Financial sustainability is critical to the Canadian medical system given that >50% of provincial budgets are currently allocated to health care spending (7). Although the incidence of burn injuries in the pediatric population is relatively low, the cost of treatment can be quite high (1,8). With scalds representing the most common pediatric burn mechanism of injury, opportunities exist to alter the current inpatient model of care paradigm to enhance health care value because the bulk of this cost is due to hospital admission.

The purpose of the current study was to analyze overall health care value (outcomes/cost) associated with pediatric scald burns not requiring surgery. We compare the management of scald burns with NCS versus SSD from both a quality perspective and a cost perspective (using bottom-up microcosting) to determine which option optimizes health care value.

METHODS

A MEDLINE search was conducted to identify all studies evaluating the use of NCS and SSD in burn wounds published in English over the previous 25 years. Search terms (either alone or in combination) included: Acticoat, Silvadene™, Flamazine™, NCS, SSD, burn(s), cost, economics, wounds, pediatric, scald(s) and dressing(s). All articles that evaluated burn wound management in the pediatric population were identified and fully reviewed independently by two of the authors. For an article to be included, SSD and/or NCS had to be the

dressings used, and burn size, healing time, hospital duration and frequency of dressing change were requisite quality metrics. Patients who required debridement and skin grafting were excluded from the present review. Based on the available cost data from the BC Children's Hospital (Vancouver, British Columbia) finance department, a bottom-up microcosting economic model was constructed for the two burn wound dressing options and these data were used as a proxy for inpatient hospital and dressing costs across Canada. A value analysis was ultimately performed.

RESULTS

Over the 25-year study interval, 356 studies investigated the use of SSD in burns, while 55 studies evaluated the use of NCS. Ultimately, six studies met the inclusion criteria and were used to determine outcomes.

Outcomes

For the studies included, mean age and burn size were equivalent between SSD and NCS. Mean time to healing was 14.9 days for NCS and 17.2 days for SSD. Mean duration of hospital stay was 14.9 days for SSD and 5.9 days for NCS. Dressings were performed twice per week for NCS and once or twice per day for SSD. Pooled data showed that although children with burns treated with SSD or NCS were of similar age (3.7 years of age for SSD and 4.2 years of age for NCS) and extent of burn injury (6.3% TBSA for SSD and 6.8% TBSA for NCS), patients treated with NCS stayed in hospital for a shorter duration and underwent only twice weekly dressing changes. Table 1 summarizes demographics, burn size and time to healing data for both groups of patients.

Cost

All costs associated with both an inpatient day in hospital as well as per-minute use of a burn treatment room were calculated using a bottom-up microcosting model. These costs were obtained from the hospital's department of finance and were estimated in Canadian dollars. Using the outcome data calculated based on days to heal, frequency of dressing changes and duration of hospital stay, the mean total cost per patient was estimated (Table 2). For SSD, frequency of dressing changes was estimated to be 1.5 dressing changes per day; although this is an unrealistic scenario, some centres perform daily SSD dressings, while others perform SSD dressings twice per day. Also, it was assumed that all dressing care would be performed by nurses in an operative/treatment room environment with a sedated patient. This scenario was used for the microcosting model based on a dollar per-minute cost of dressing care. Given these assumptions, the estimated mean total cost per patient to the health care system was \$61,140 for SSD and \$17,220 for NCS.

DISCUSSION

Advances in the management of burn injuries have improved the quality of life for the pediatric scald burn population. However, there are few publications outlining the treatment costs or the cost effectiveness of these new advances (1,6,8,9,10). Although achieving optimal closure of burn wounds is of primary importance, the need to find and provide models of care that allow fiscal sustainability are also critical (11-13). To perform an economic evaluation in a limited field such as burns, the resources spent for effective treatment need to be quantified (8,16,18). In pediatric burn care, the major cost in the acute setting is associated with hospital stay, multiple burn dressing or operative procedures, and the use of skin substitutes (11,12,14). Additional resources may also be incurred during the rehabilitation period or for operative interventions related to scar pathology, but these were beyond the scope of the present study. Our study population was representative of the most common clinical scenario: small-to-medium size acute scald burns that did not require operative intervention.

Safety and efficacy

Safety and efficacy are paramount and are prioritized over cost. Our literature-based evaluation showed that NCS is a safe option for scald burns and possibly more efficacious than SSD, given a faster time to heal. Furthermore, NCS dressings allow a reduced number of sedations and/or analgesia, decreased frequency of dressing changes and reduced risk of infection (12,15). In a study evaluating feedback from 20 caregivers, NCS was relatively easier to remove, with only minor complications cited, and pain was not a concern (11). Although both dressings are safe, our review suggests that SSD has been surpassed in the past decade by more efficacious burn dressings based on NCS technology. It must be noted that these are relatively small-to-medium size burns that often have the propensity to heal without the need for surgical excision.

Cost analysis

We are currently in an era of fiscal accountability in health care. An economic analysis of treatment paradigms is paramount; however, a cost-effective treatment should not compromise clinical outcomes (6). Actual cost of care is difficult to measure in a socialized system and most health care cost studies are based on reimbursement data. Bottom-up microcosting is a useful way of estimating the treatment cost for a small group of patients treated in facilities where there is no reimbursement system and no bills are generated for patients (16,17).

Other authors have attempted to determine costs associated with SSD versus NCS: in one study, the total costs for SSD were found to be approximately \$30,000 higher than for NCS (US\$109,357 versus US\$78,907) (15), which was consistent with, although slightly lower than, our findings. Another study calculated theoretical costs comparing NCS and SSD using an equation that included cost of dressings, sedation and analgesia, nursing time as well as the number of dressings performed (11). The theoretical cost for a 1%, 5%, 15%, 25% TBSA burn was significantly higher for SSD than NCS (11). At our centre, pediatric scald burn injuries are routinely managed using NCS and often on an outpatient basis after an initial admission for stabilization and pain control (18).

The principles of opportunity cost and marginal benefit are critical to the discussion of service prioritization in socialized health care. Opportunity cost represents the lost benefit from the next best use of resources (4,19,20). The opportunity cost of an inpatient bed is the ability to admit another child after a procedure, accept a child from the emergency department or accept a transfer from an outside hospital. The concept of marginal benefit relates to the benefit gained from adding the next unit of resources for a given value stream. For example, if one extra bed were to be made available, that bed could be given to another child, permitting another admission to occur (4). One issue that is relevant in the present discussion is whether the almost \$44,000 of 'savings' would actually be realized in the Canadian setting. In health care economics parlance, these are referred to as

'dark green' dollars (in contrast to 'light green' dollars, which refer to paper savings that are not realizable). The primary consideration in the present example is whether the human resources associated with closing beds would be able to be adjusted to a sufficient amount that monies attached to a reduction in staffing due to lower volume could be harvested. Assuming budgets would be maintained and staffing unchanged, in our fixed capacity and high-utilization Canadian system, what the opportunity cost that another available bed provides is the benefit for another child to be admitted, thereby 'realizing' another admission to hospital.

CONCLUSION

Although miniscule in comparison with the overall gross domestic product associated with health care, the debate surrounding an outpatient model of burn care using NCS burn dressings is a suitable example of practice change to increase health care value. If an equivalent or superior outcome can be achieved at a discounted cost, per Porter's (4) formula, value is enhanced. Furthermore, the psychosocial ± financial costs associated with familial well being achieved with an outpatient model of care has not been explored and would likely add additional social value to this proposition.

The present analysis reviewed germane publications over a 25-year interval, with the findings that an outpatient model of burn care for small-to-medium size scalds results in preservation of quality and safety metrics. The financial model presented was based on bottom-up microcosting and illustrates almost \$44,000 of cost savings per patient that could be realized with such a practice change. Individuals managing or influencing health care policy or practice must create innovative solutions to increase value in health care. An outpatient model for pediatric scald burn care is just one example of such an initiative.

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