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A silver coated dressing reduces the incidence of early burn wound cellulitis and associated costs of inpatient treatment: Comparative patient care audits

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Abstract

In 2000 and 2002, the Royal Perth Hospital (RPH) Burn Unit, Western Australia, conducted two 'before and after' patient care audits comparing the effectiveness and cost of Silvazine™ (silver sulphadiazine and chlorhexidine digluconate cream) and Acticoat™, a new dressing product for in-patient treatment of early burn wounds. The main outcome variables were: burn wound cellulitis, antibiotic use and cost of treatment. Two patient care audits and a comparative sample were used. The two regimes audited were, 'standard treatment' of twice daily showers or washes with 4% chlorhexidine soap and Silvazine™ cream as a topical dressing (2000, $n = 51$), compared with the 'new treatment' of daily showers of the burn wound with 4% chlorhexidine soap and the application of an Acticoat™ dressing (2002, $n = 19$). In 2002, costs were also examined using a sample of matched pairs ($n = 8$) of current and previous patients. The main findings were: when using Acticoat™ the incidence of infection and antibiotic use fell from 55% (28/51) and 57% (29/51) in 2000 to 10.5% (2/19) and 5.2% (1/19) in 2002. The total costs (excluding antibiotics, staffing and surgery) for those treated with Silvazine™ were US$ 109,357 and those treated with Acticoat™ were US$ 78,907, demonstrating a saving of US$ 30,450 with the new treatment. The average length of stay (LOS) in hospital was 17.25 days for the Silvazine™ group and 12.5 days for the Acticoat™ group—a difference of 4.75 days. These audits demonstrate that Acticoat™ results in a reduced incidence of burn wound cellulitis, antibiotic use and overall cost compared to Silvazine™ in the treatment of early burn wounds.

Keywords: Burn wound cellulitis; Infection; Cost; Silvazine™; Acticoat™

1. Introduction

1.1. Setting

The Royal Perth Hospital (RPH) Burn Unit provides a state wide service for the adult population of Western Australia. This nine bed unit admitted an average of 199 people per year from 1991 to 2003, with the number of burn injuries increasing over this period from 162 in 1991 to 229 admissions in 2003.

1.2. Problem

Over the last decade, clinicians in this Burn Unit have expressed concern over the increasing incidence of early burn wound cellulitis and the associated increased use of antibiotics. During this period burn wounds were frequently observed to be characterised by one or more signs and symptoms of burn wound cellulitis within 3 days of admission. These signs and symptoms include elevated body temperature of 38.5 °C or above for at least 24 h, redness measuring 2 cm or more from the wound edges and positive wound swab cultures. Patients were often treated with antibiotics when any of these signs or symptoms was apparent.

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1.3. Burn wound cellulitis and infection

Burn wound cellulitis is commonly characterised by erythema of the surrounding unburnt skin (1–2 cm beyond the wound), pain and oedema extending beyond the usual rim of inflammation commonly seen in burns in the first 48–72 h [1]. Burn wounds are susceptible to infection due to impairment of the skin barrier and reduction in cell mediated immunity [2,3]. Infection or sepsis is present in a burn wound when deposition and multiplication of bacteria in the tissue is associated with a host reaction or invasion of nearby healthy tissue and a bacterial count of $10^5 g^{-1}$ of tissue [4,5].

Burns result in destruction of tissue and provide a wound environment at risk of infection and therefore septicaemia [6,7]. The risk is further exacerbated by immuno-suppression associated with the burn injury [8]. As well as the increasing number of infections, the recent emergence of Methicillin resistant *Staphylococcus aureus* (MRSA) and multi-resistant *Pseudomonas aeruginosa* is of concern as the control of burn wound sepsis is vital for patient survival [8,9]. Multi-resistant *P. aeruginosa* outbreaks are seen in Burn and Intensive Care Units (ICU) more frequently [6–9]. Recent advances in resuscitation methods and support systems in the management of the severely burnt patient have reduced the mortality rate associated with burns but infection remains a major cause of morbidity and mortality [7,8]. Topical anti-microbials and early excision of the burn eschar have reduced burn wound infection [10].

One researcher reported that multiple daily dressing changes increased the risk of nosocomial infection, escalated the cost of care, damaged new epithelial tissue and caused pain [11]. Another study indicated that there were reduced costs in small partial thickness burns with use of a polyurethane dressing as compared to the conventional daily silver sulphadiazine cream dressings [12].

1.4. Acticoat™

The introduction of Acticoat™ to Australia in 2001 with the manufacturer's claims this dressing reduces the occurrence of infection provided an opportunity to improve clinical practice in the treatment of burn wounds.

Acticoat™ is a new dressing facilitating the delivery of silver to the burn wound surface [14]. It contains nanocrystalline silver which, when moistened with water, continues to release silver ions onto the wound surface [14]. The in vitro anti-microbial action of silver can destroy, within 30 min, both Gram positive and negative bacteria as well as *Vancomycin resistant enterococci* (VRE) and Methicillin resistant *S. aureus* [10,14,17]. This action is accomplished by the silver ions binding to tissue proteins causing a structural change in the bacterial cell membranes [17]. The silver then binds and denatures the bacterial DNA and RNA, thus inhibiting replication [6,13–17].

The action of Acticoat™ is faster than silver sulphadiazine cream in destroying *Escherichia coli*, *S. aureus* and *P. aeruginosa* [17]. An in vitro study comparing four dressings found that Acticoat™ resulted in the most rapid anti-microbial effect compared to Actisorb Plus™, Contreet H® and Avance [15]. The authors cautioned the extrapolation of laboratory findings to the clinical situation [15]. In contrast to these findings, another in vitro study found Silvazine™ was a more effective anti-microbial against a number of burn wound pathogens than Acticoat™ [18]. Another investigation reported that when applied to donor sites, Acticoat™ treated areas healed at a slower rate than those treated with Allevyn™ foam [19].

The conflicting evidence prompted this study, aimed at determining: the incidence of infection and antibiotic use with Silvazine™ as 'standard treatment'; the effectiveness of the 'new treatment' Acticoat™ in reducing infection; preliminary information on cost savings when using Acticoat™ in the early management of burn wounds.

2. Methods

2.1. Introduction

This patient care audit of changes in clinical practice over 2.5 years, reports baseline data from the findings of a first review of 'standard treatment' (Silvazine™) in 2000; the introduction of a 'new treatment'—(Acticoat™) in 2001; a comparison in 2002 of Acticoat™ including a sample with historical controls receiving 'standard treatment'—Silvazine™; a preliminary comparative costing of the two treatment regimes, followed by another patient audit in 2002.

2.2. Definitions

Early burn wound cellulitis: One or more signs or symptoms of infection including redness or erythema extending more than 2 cm from the wound edges, elevated body temperature of 38.5 °C or above for at least 24 h and/or a positive wound swab culture (10^5 g of tissue) within 3 days of admission [1,20].

Antibiotic use: Number of types of antibiotics administered within 2 days of admission.

'Standard treatment': Twice daily showers or washes of the burn wound with chlorhexidine 4% soap. Silvazine™ cream as a topical dressing.

'New treatment': Daily shower of the burn wound with chlorhexidine 4% soap. Application of Acticoat™ dressing.

2.3. Outcome measures

Burn wound cellulitis, length of stay in hospital, dressings and antibiotic use and cost.

In this preliminary investigation, no specific cost estimates were provided for surgery, cultured epithelial autograft (CEA), individual patient antibiotic therapy or staffing.

2.4. Audits

2.4.1. Audit 1: 'Standard treatment'—Silvazine™: January, February and September–December 2000.

Sample: A convenience sample of 87 people admitted with burn injuries in January, February and September–December 2000 were eligible for inclusion in the audit. Those admitted with an existing wound infection, staying in hospital for less than 3 days, admitted to ICU or admitted for burn reconstructive surgery were excluded from this review ($n = 36$) leaving a sample of ($n = 51$) (Table 1).

Using a specifically designed form, one investigator collected data on the occurrence of wound cellulitis and the level of antibiotic use within the first 3 days following admission.

2.4.2. 'New treatment'—Acticoat™: commencing December 2001

The introduction of Acticoat™ dressings for the treatment of all patients admitted with new burn injuries occurred in December 2001. The water-moistened Acticoat™ dressings were applied directly to the burn wound with the blue side opposing the wound. This application was followed by water-moistened gauze to activate the dressing. The Acticoat™ dressing was changed up to 3 days after application, often daily, when the colour of the dressing altered from dark blue/grey to a coppery colour.

2.4.3. Audit 2: May and June 2002

Sample: Another convenience sample of 49 people admitted in May and June 2002 with burn injuries were eligible for inclusion in the audit. Those admitted with an existing wound infection, staying in hospital for less than 3 days, admitted to the ICU or for burn reconstructive surgery were excluded from the review ($n = 30$) leaving a sample of ($n = 19$) (Table 1).

2.4.4. Comparative sample: comparing Silvazine™ and Acticoat™: May 2002

Sample: A sample of four patients admitted with burn injuries treated with Acticoat™ were selected, matched and compared with four historical controls from 2000 treated with Silvazine™ ($n = 8$). The inclusion criteria specified an upper limb burn injury and to ensure compliance with treatment regimen, no recorded history of psychiatric illness. Pairs were matched on the burn percentage total body surface area and depth (superficial, partial or full thickness) (Table 3). Clinical notes provided data on Silvazine™ (historical controls) and prospectively for Acticoat™. The comparative sample provided further information on infection, treatment, antibiotic use and costs as part of audit 2.

2.5. Ethics

Under the Royal Perth Hospital ethics guidelines this investigation was classified as an audit.

3. Results

Table 1 shows Acticoat™ resulted in a decrease in the incidence of burn wound cellulitis and antibiotic use from 55% (28/51) and 57% (29/51) in 2000 to 10.5% (2/19) and 5.2% (1/19) in 2002.

Table 2 shows that flame burn was the most common agent of burn injury in both groups, followed by scalding. Contact burn was the next most frequent with acid, electrical and molten metal burns and sunburns accounted for a minor percentage in both groups.

Table 3 shows the Silvazine™ group (audit in 2000) had a higher incidence of burn wound cellulitis (49%) than the Acticoat™ group (audit in 2002), which was 10.5%. The findings of the audit in 2000 showed two patients with positive swab culture had no other signs or symptoms of infection and two other patients with positive swab culture, had one other sign or symptom of infection. The findings of the audit in 2002 showed two patients with positive swab culture but with no signs or symptoms of infection.

Table 1
Comparison of the incidence of burn wound cellulitis and antibiotic use between Silvazine™ and Acticoat™ in early burn wounds

Silvazine™ year 2000 ($n = 51$)				Acticoat™ year 2002 ($n = 19$)			
Occurrence of burn wound cellulitis[a]		Antibiotic usage[b]		Occurrence of burn wound cellulitis[a]		Antibiotic usage[b]	
n	%	*n*	%	*n*	%	*n*	%
28	55	29	57	2	10.5	1	5.2

n: number, %: percentage.

[a] One or more signs of burn wound cellulitis-redness 2 cm or more from wound edges, elevated body temperature 38.5° C for at least 24 h or positive wound swab culture.

[b] Number of types of antibiotics administered within 2 days of admission.

Table 2
Average TBSA and types of burn for the Silvazine™ and Acticoat™ groups

Category	Silvazine™ (n = 51)		Acticoat™ (n = 19)	
	n	%	n	%
Flame burn	25	49	11	57.8
Scalds	17	33.3	6	31.5
Contact burn	3	5.8	1	5.2
Acid burn	2	3.9	0	0
Sunburn	1	1.9	0	0
Molten metal	1	1.9	0	0
Electrical burns	0	0	1	5.2
Average %TBSA	–	9.5	–	9

%TBSA: % total body surface area of burn.

Table 3
Incidence of wound cellulitis signs and symptoms

Signs/symptoms	Silvazine™ (n = 51)		Acticoat™ (n = 19)	
	n	%	n	%
Redness/erythema	21	47	0	0
Elevated body temperature	15	29.4	0	0
Redness + elevated body temperature	9	17.6	0	0
Positive swab	4	7.8	2	10.5
Redness + elevated body Temperature + positive swab	25	49	2	10.5

Table 4
%TBSA burns and depth of burns for matched pairs

Pairs (n = 8)	Percentage total body surface area (%)		Depth of burn
	Silvazine™	Acticoat™	
Pair A	10	8	Superficial to partial thickness
Pair B	10	10	Partial thickness
Pair C	9	14	Superficial partial thickness
Pair D	18	20	Deep partial thickness

Table 4 shows the %TBSA and the depth of burns for the four matched pairs. Pairs A, B and D had approximately similar size burns (2% difference in pairs B and D) and pair C had a 5% difference in burn size. All the pairs had similar depth burns.

Table 5 shows the cost of dressings, LOS, the number of procedures and antibiotics used for the four pairs of patients. The average LOS for the Silvazine™ group was 17.25 days, while the Acticoat™ group was 12.5 days, a difference of 4.75 days. One patient (25%) in the Acticoat™ group required surgery, while all four patients (100%) in the Silvazine group required surgery. Two patients (50%) in the Acticoat™ group received antibiotic therapy as opposed to three patients (75%) in the Silvazine™ group.

The total cost (excluding individual antibiotic, surgery, CEA and staffing costs) for those treated with Silvazine™ was US$ 109,357 and those with Acticoat™ US$ 78,907 demonstrating a saving of US$ 30,450. The average cost per patient for the Silvazine™ group was US$ 27,339 and the Acticoat group was US$ 19,726, a difference of US$ 7613 per patient. In this comparison of cost, the average dressing cost was US$ 1533 per patient for the Silvazine™ group and US$ 946 per patient for the Acticoat™ group.

4. Discussion

4.1. Main findings

The findings of this investigation indicated that the incidence of burn wound cellulitis decreased with use of Acticoat™. As illustrated in Table 1, the incidence of burn wound cellulitis dropped from 55% (28/51) in 2000 to 5.2% (1/19) in 2002. As a consequence of this there was a decrease in the use of antibiotics from 57% (29/51) in 2000 to 10.5% (2/19) in 2002. Similar results were found in a matched paired randomised controlled investigation of 30 burn patients treated with Acticoat™ or 0.5% silver nitrate solution dressings and were evaluated for the level of antimicrobial effectiveness [10]. Tredget et al. found that the frequency of burn wound sepsis ($>10^5$ organism/g tissue) was less in Acticoat™ treated wounds than those treated with silver nitrate 0.5% solution dressings [10]. They also reported less frequent occurrence of secondary bacteraemia from infected burn wounds with Acticoat™ group [10]. Three other experimental investigations comparing the effect of Acticoat™ with various silver dressings demon-

Table 5
Comparison of costs between Silvazine™ and Acticoat™ dressings (2002)

Pairs (n = 8)	Treatment	Antibiotic doses	Surgery	LOS[b] (number of days)	Cost[a] ($A)	Dressings cost ($A)	Total cost ($A)
Pair A	Silvazine™	0	1	15	22,500	1198	23,698
	Acticoat™	2	0	8	12,000	563	12,563
Pair B	Silvazine™	1	1	13	19,500	615	20,115
	Acticoat™	0	0	11	16,500	891	17,391
Pair C	Silvazine™	1	1	18	27,000	1253	28,253
	Acticoat™	0	0	10	15,000	638	15,638
Pair D	Silvazine™	1	1	23	34,500	2791	37,291
	Acticoat™	1	1	21	31,500	1815	33,315

$A: Australian dollar.
[a] $A 1500 per day.
[b] Length of stay.

strated that Acticoat™ performed better and faster in killing bacteria than the other silver dressings [15–17].

The average %TBSA burns in both audits were similar (9.5% in 2000 and 9% in 2002). The types of burn for both years were comparable in that flame burn is most prevalent, followed by scalds (Table 2). These findings typify the usual population in many burn units.

Findings in the 2000 audit indicated that 49% of the sample (25/51) had signs and symptoms of burn wound cellulitis without any positive swab culture results. Conversely two patients (3.9%) had positive swab culture results without any signs and symptoms of burn wound cellulitis, while two other patients (3.9%) had positive swab results with either one or two other signs and symptoms of burn wound cellulitis. The 2002 audit revealed two patients (10.5%) had positive swab culture results without any signs or symptoms of burn wound cellulitis (Table 3). These two patients were community patients with non multi-resistant *S. aureus* (NMRSA). It is common for these patients to have positive cultures of NMRSA without signs or symptoms of infection. One investigator questioned the usefulness of surface swab cultures especially within the first 24 h of admission and stated from their findings that these results rarely alter or provide direction for therapy [21]. They demonstrated there was a 0.01% (1/111) positive swab culture result within the first 24 h of admission [21]. They suggested biopsies for histological studies should be used if burn wound infection is suspected [21].

The cost estimates and other findings for the matched paired comparison between Silvazine™ and Acticoat™ indicated that patients treated with Acticoat™ spent less days in hospital and were discharged earlier than those treated with Silvazine™. There was a total cost savings of US$ 30,450 (excluding costs for staff, surgery, CEA and antibiotic costs) with the four patients treated with Acticoat™. As seen in Table 5, the average cost per patient for the Silvazine™ group was US$ 27,339 and for the Acticoat™ group the average cost per patient was US$ 19,726, a cost saving of US$ 7613 per patient. These findings indicated that using Acticoat™ for burn wound treatment reduces the ultimate costing of treating burn patients. It can be seen from Table 5 that the number of patients having surgery was far less in the Acticoat™ group (0%) than in the Silvazine™ group (100%). This would have contributed to the higher costs and LOS in hospital for the Silvazine™ group. From these findings, it is indicated that Acticoat™ reduces surgical intervention requirements compared with Silvazine™ burn wound treatment. With the reduced incidence of burn wound cellulitis as seen in Tables 1 and 3, the use of antibiotics was also reduced in the Acticoat™ patient group (Table 5). There is a lack of research in the literature regarding antibiotic use or cost for Acticoat™ versus Silvazine™ dressings in burn management.

Interestingly, staff working with previous standard wound care regimens (Silvazine™) and the new method of Acticoat™, made subjective observations that patient comfort has improved as they now only required once daily or third daily treatments. This led to verbalisation of improved feeling of well being, with patients requiring less analgesia, improved mobility and increased participation in activities of daily living. Similar findings were reported by three other investigators [10–12].

4.2. Contraindications for using Acticoat™ or silver

The main contraindications in using Acticoat™ is argyria, which may arise when silver is applied on open wounds where the silver salts when released in the presence of light precipitates into black silver sulphide [22,26]. This causes the wound and the surrounding skin to become brownish black. Researchers state that this staining is not permanent [22,26]. Research into silver toxicity is not well documented but Silvazine™ has been shown to cause leukopenia [22–26]. Reports of toxicity are low; however, more research is needed on the negative effects of silver in burn wound management.

4.3. Limitations

One of the main limitations of these comparative examinations is the lack of random assignment of treatments, therefore, not minimising selection bias. Another drawback is the small sample size ($n = 8$) of the control sample.

5. Conclusion

The findings of these audits provide some evidence that Acticoat™ is the dressing of choice post burn admission, resulting in reduced rates of burn wound cellulitis, antibiotic use and a reduction in cost compared to Silvazine™. This investigation supports a change in the clinical practice of early burn wound management and demonstrates the evidence based research needed to inform practice. The Burn Unit at RPH has adopted the practice of applying Acticoat™ on all partial to full thickness burn admissions for the first 3 days of admission and/or the period prior to debridement.

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