

EVIDENCE-BASED PRACTICE

Larval debridement therapy: an economic, scientific and clinical evaluation

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Larval debridement therapy: its role in chronic wound healing

Larval therapy, also known as maggot therapy or biosurgery, has a long history of use in the treatment of chronic and infected wounds. Larvae were first used for debridement in the American Civil War and First and Second World Wars and were used successfully to treat several cases of osteomyelitis (Buchman and Blair, 1932). With the advent of antibiotics in the 1940s, however, the practice of larval debridement therapy (LDT) declined.

More recently, interest in LDT has resurged due in part to the rise in chronic wounds and the emergence of antibiotic resistant strains of bacteria, such as methicillin-resistant *Staphylococcus aureus* (MRSA) (Davies, 2013). This has necessitated finding other effective methods to facilitate cleansing and removing necrotic material, and combat infection without damaging the healthy tissue beneath.

Debridement should be considered as an essential part of the process of caring for a patient with a wound (Wounds UK, 2013). However, although there is currently no robust evidence to support any particular method of debridement, it is generally accepted that necrotic/infected tissue must be removed as quickly and efficiently as possible (Wounds UK, 2013). In this document, Bennett et al (pp2–11) describe a first attempt to evaluate the cost-effectiveness of LDT compared to all relevant comparator therapies in UK clinical practice. Although the data limitations mean there is a degree of uncertainty in the results, the model provides useful information on the comparative costs and benefits of debridement therapies, with LDT remaining cost-effective under all scenarios tested in a range of sensitivity analyses. This important study identifies gaps in available evidence relating to debridement and highlights the need for further research, particularly in the areas of quality of life and resource use to support clinical decision-making.

Effective debridement can help progress a wound to healing and is associated with reduced exudate, a

reduction in odour and the appearance of granulation tissue in the wound bed (Vowden and Vowden, 2011). Larvae of the greenbottle fly (*Lucilia sericata*) physically feed on dead tissue, cellular debris and exudate present in sloughy wounds. This process involves the physical actions of the larvae and presence of proteolytic enzymatic digestion in the wound.

The second paper in this document by Dr Yamni Nigam (pp12–16) reviews the scientific studies that explain the actions of LDT in chronic and infected wounds. These confirm the role of larvae in wound debridement, while shedding new light on their antibacterial activity: larval secretions may have a significant inhibitory effect on bacteria and be capable of disrupting biofilms, which are even harder to eradicate. Larval secretions may also be important in reducing chronic inflammation, helping to steer the wound towards healing. Science is starting to tell us a great deal about the mechanisms that underlie the actions of larvae; clearly, this is just the beginning and much more work is required.

In the third paper, Perricone et al (pp17–19), describe setting up the LDT service at the Blackpool Teaching Hospitals. This was initially established within the hospital and led by the vascular team with involvement of the tissue viability nurse advisor. Subsequently, the service has expanded to include community care, providing patients with good access to LDT. Although the initial intention was to target hospital patients who were unfit for surgical intervention, larval therapy is no longer used as a last resort; rather it is being used proactively to clean and close wounds quickly. However, these clinicians recognise the need to quantify the clinical and cost benefits of LDT and the vascular team is currently undertaking a case-series evaluation using medical photography, data collection and follow-up. They hope this will lead to more appropriate referrals and ultimately help to improve patient outcomes.

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Cost-effectiveness of interventions for chronic wound debridement: an evaluation in search of data

KEY WORDS

- ▶ Wound debridement
- ▶ Economic evaluation
- ▶ Cost-effectiveness
- ▶ Cost utility

Standard practice in the management of chronic hard-to-heal wounds includes debridement; however, to date, no comprehensive economic evaluations of all debridement interventions available in the UK have been reported. **Aims:** This analysis set out to evaluate the cost-effectiveness of larval debridement therapy (LDT) compared with all relevant comparator therapies in UK clinical practice. **Methods:** A decision-tree model was developed to represent the typical treatment of a single patient in clinical practice, comprising a series of monthly treatment cycles over 12 months. **Results:** Initiating treatment with LDT is estimated to be a less costly and more effective debridement strategy than initiating treatment with any of the comparator debridement methods evaluated in the base case. Data limitations and necessary modelling assumptions lead to considerable uncertainty in the modelling results; however, LDT remained cost-effective under all scenarios tested in a range of sensitivity analyses. **Conclusions:** The authors suggest that to understand better the comparative costs and benefits of debridement therapies and to support evidence-based decision-making, further research is needed to improve evidence in this area, particularly relating to quality of life and the resource use associated with therapies to which cost-effectiveness results were sensitive.

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The efficient and effective allocation of healthcare resources is vital in the UK and elsewhere in Europe, as the pressure of delivering high-quality healthcare within a finite budget increases. Healthcare decision-making must be grounded in evidence and incorporate information about both the costs and benefits (health outcomes) of healthcare interventions. Economic evaluations provide this synthesis of economic and clinical

information, comparing one intervention with a competing alternative in terms of both their costs and consequences. Such analyses may be undertaken prospectively, for example, alongside a randomised controlled trial (RCT), or through decision analytic modelling approaches.

Box 1 below summarises the different types of economic evaluation that can be undertaken in healthcare.

Box 1: Different types of economic evaluation

- ▶ **Cost-minimisation analysis (CMA):** outcomes of the two (or more) comparators are assumed equal, thereby resulting in an assessment based solely on comparative cost. Making the assumption of equal outcomes rarely holds in practice.
- ▶ **Cost-effectiveness analysis (CEA):** outcomes are one dimensional and measured in naturally occurring units, such as changes in blood pressure or mortality. The incremental cost-effectiveness ratio (ICER) is calculated to determine the additional cost incurred to achieve an additional unit of outcome. If one intervention is both more expensive and more effective than its comparators, lower ICER values represent better value for money and a value judgement will be required to assess whether the cost per extra unit of outcome is worthwhile.
- ▶ **Cost-utility analysis (CUA):** an extension of cost-effectiveness analysis in which multi-dimensional health outcomes are reduced to a single index using health utilities and are expressed as quality adjusted life years (QALYs). The use of a standard measure of health benefit enables broader comparisons of cost-effectiveness to be made across different diseases and populations.
- ▶ **Cost-benefit analysis (CBA):** costs and outcomes are valued in a common unit – usually money. The financial value of the benefits is compared to the costs, allowing the selection of the intervention with the overall highest financial benefit.

In the UK, CUA is the preferred approach to economic evaluation used by national bodies such as the National Institute for Health and Care Excellence (NICE), the Scottish Medicines Consortium (SMC) and the All Wales Medicines Strategy Group (AWMSG) when making decisions about what interventions should be used in the UK.

Chronic wounds

Chronic wounds affect hundreds of thousands of people, particularly older people. These wounds are painful and debilitating, resulting in reductions in quality of life. In 2007, Posnett and Franks estimated that chronic wounds affected 200,000 individuals annually in the UK, at a cost to the NHS of £2.3–£3.1 billion per year (2005/6 prices).

Wound debridement

Standard practice in the management of chronic hard-to-heal wounds includes debridement to remove dead tissue and activate healing by removing slough, exudate and bacteria. A variety of approaches may be used to accomplish this, including larval debridement therapy (LDT), autolytic dressings (hydrogel, honey), mechanical (ultrasound), and surgical treatments (including sharp debridement and hydrosurgical). An economic evaluation comparing LDT to hydrogel was conducted alongside the VenUS II (Dumville, 2009) RCT of LDT in the management and healing of leg ulcers; however, to date, no comprehensive economic evaluations of all debridement interventions available in the UK have been reported.

The aim of this analysis was to evaluate cost-effectiveness of LDT in wound debridement compared to all relevant comparator debridement therapies available in UK clinical practice, in the form of a CUA.

METHODS

The evaluation reported here was conducted from the perspective of the UK National Health Service (NHS) and Personal and Social Services (PSS) and was informed by relevant peer-reviewed publications, clinical experts in wound care and current clinical practice in the UK. After initial discussions with clinical experts, a structured literature review (to be reported elsewhere), was undertaken to support the development of a model evaluating the cost-utility of LDT against six comparator debridement therapies:

mechanical, hydrogel, honey, surgical, sharp, and hydrosurgical.

Identified literature describing economic evaluations, RCTs, observational studies and reviews published between January 2006 and December 2011 were reviewed to provide clinical and economic data for modelling. The review highlighted a dearth of good quality studies published in recent years that evaluated clinical- and/or cost-effectiveness of therapies for the debridement of wounds and promotion of healing, not only for LDT, but for all methods of debridement. Given this problem, where the literature review did not provide sufficient data to define and populate the model fully, health professionals in the field of wound care were consulted to inform plausible assumptions.

Model description

A decision-tree model was developed in Microsoft Excel to replicate the typical treatment of a single patient and is, of necessity, a simplification of the complex treatment of wounds and patient care in real life. Not all forms of debridement are suitable for all wounds and patients; however, this complexity is not represented in the model and comparisons are made only for those wounds for which the considered debridement therapies are appropriate. There is considerable variation in wound care and the treatment pathways seen for debridement in a clinical setting may differ depending on whether care is led by a vascular team or tissue viability nurse. Despite this variation of practice this model aims to represent an 'average' case. Expert clinical opinion informed a number of assumptions incorporated in the model structure (Box 2), which comprised a series of monthly cycles over a one-year horizon. A basic schematic of the model is presented in Figure 1.

A patient entering the model receives the debridement therapy of interest during Month 1 (LDT or one of its comparators). If debridement is not achieved during this period, the patient may receive a different therapy in the next cycle or undergo a clinical intervention, terminating the use of all debridement therapies. Up to six cycles of debridement therapy are modelled in total, after which any undebrided wound leads to clinical intervention.

Within the six-month treatment period, patients are assumed to move from one therapy to another with equal probability, with the exception of surgical-type therapies: surgical, sharp and hydrosurgical

KEY POINTS

- ▶▶ Healthcare spending is under pressure in publically-funded health services.
- ▶▶ Chronic hard-to-heal wounds are a considerable burden on health services and have a high human impact.
- ▶▶ Wound debridement is standard practice to activate healing, but few clinical and economic evaluations are found in the literature.
- ▶▶ Economic evaluation of available wound debridement interventions is important to support healthcare decision-making, but lack of data makes this type of evaluation challenging.
- ▶▶ Estimates from economic modelling reported here suggest that initiating debridement with LDT is a cost-effective strategy.

Box 2: Key modelling assumptions

- ▶▶ The same debridement therapy is not used in consecutive months
- ▶▶ Surgical, sharp and hydrosurgical debridement therapies are not used in consecutive months
- ▶▶ The probability of clinical intervention increases over time for wounds not debrided at the end of a cycle of treatment
- ▶▶ Amputation (lower limb) is the clinical intervention modelled as the 'terminating' event for the treatment of undebrided wounds
- ▶▶ The probability of clinical intervention is higher for autolytic therapies, based on the rates of amputation reported by Ribu et al (2008)
- ▶▶ A fixed cost and effect was applied to the probability of wound infection with each treatment

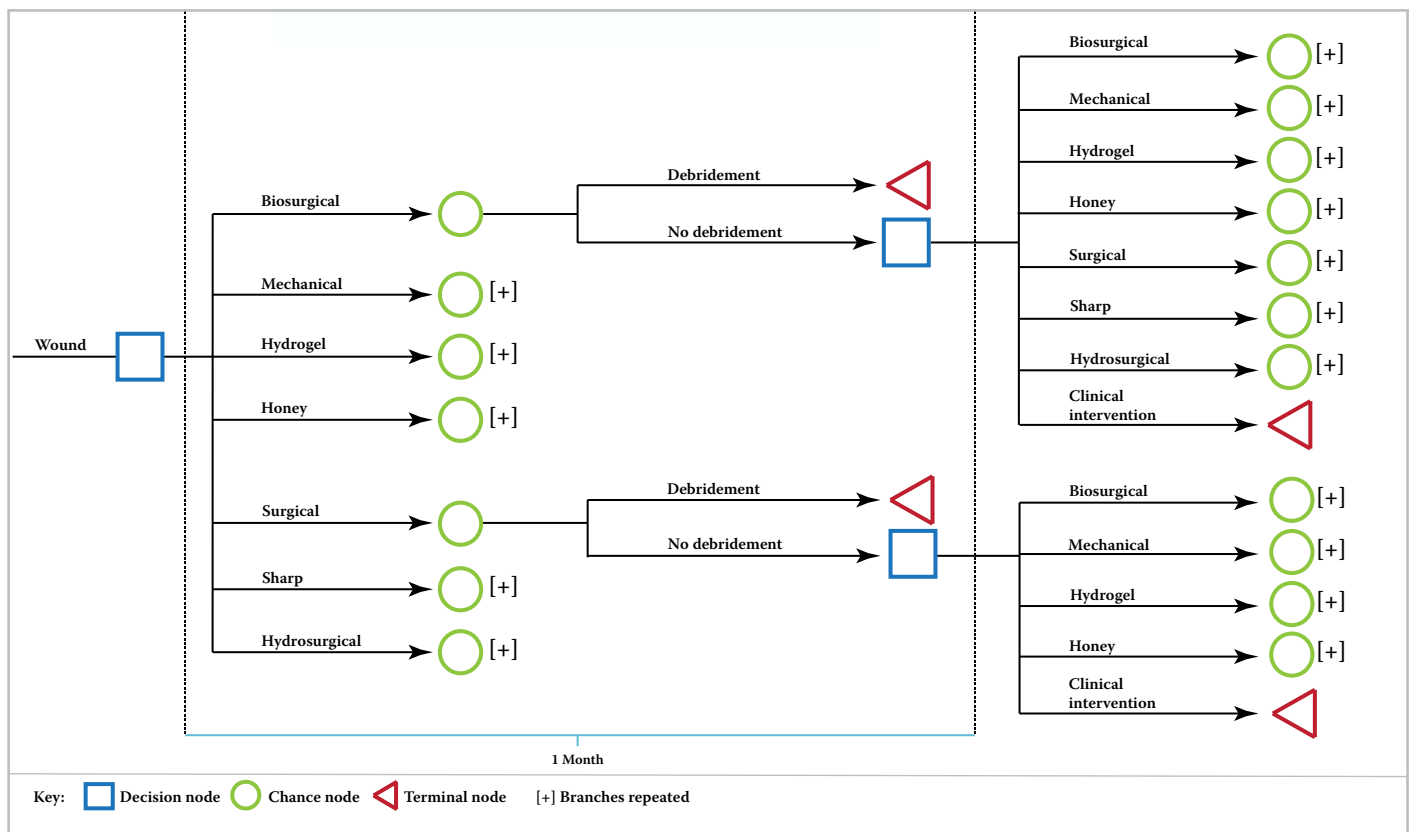


Figure 1: Schematic representation of the cost-effectiveness model.

debridement. Based on expert advice, more than one attempt may be made to achieve debridement with surgical-type therapies within a one-month cycle, although the number of procedures is restricted by the risks associated with general anaesthesia. As with other therapies, if debridement is not achieved with this therapy within one month, a different therapy may be used in the following month; however, surgical-type therapies will not be used successively.

Based on an informed, simplifying assumption, all 'terminating' clinical interventions were modelled as amputation relating to a lower limb or foot wound. In practice, patients might alternatively receive angioplasty, or other major interventions that address

the underlying clinical problem responsible for the non-healing wound. This assumption may be considered conservative since other options may deliver greater post-intervention quality of life, while the modest difference in costs between interventions is unlikely to have a significant impact on the analysis.

Clinical effectiveness

Parameter values for the following variables were derived from the published literature where possible and based on informed assumptions where required: probability of debridement; probability of infection; probability of adverse events during treatment; and probability of clinical intervention (Table 1).

Preference was given to information related to bagged larvae where data for both loose and bagged larvae were reported in the literature, as it is the most commonly used form of LDT currently commercially available.

Rates of clinical intervention

In the base case scenario, clinical intervention (amputation) rates were assumed to be low during the first six months of treatment. After the first month of debridement therapy, 0.5% of modelled patients who had undergone unsuccessful LDT, mechanical, surgical, sharp, or hydrosurgical debridement, received clinical intervention and ceased debridement therapy. Over the following months, the modelled proportion of patients with undebrided wounds receiving clinical intervention rose: 0.5%, 1%, 2% and 2.5%. The equivalent rates for autolytic therapies were 1%, 1%, 2%, 4% and 5%. At the end of Month 6, any wounds still not debrided resulted in a clinical intervention.

Healthcare resource use and cost data

Table 2 details the cost inputs implemented in the base case. Where available healthcare resource use and costs were derived from published sources, PSSRU Unit Costs (2011) and National Reference Costs (2011). Where necessary published costs were

inflated to 2010/2011 costs using appropriate OECD PPP indices (OECD, 2010/11). Where published resource use and related cost data were not available, estimates were elicited from clinical experts based on their experiences of current practice.

The cost of LDT, published by Dumville et al (2009), was updated and calculated from the weighted average cost per treatment from the manufacturer’s (Biomonde Ltd) sales data (Data on file), to determine a cost per application of LDT (£234). This cost is higher than the costs of LDT used by Dumville et al (2009) and, thus, any bias introduced by its implementation will be in favour of the comparator therapies.

Quality Adjusted Life Years

To calculate quality adjusted life years (QALYs), utility values^{*} were required to weight the life years associated with the various treated and untreated health states within the model. These were derived from published literature where possible and assumptions made based on other treatment outcomes where necessary. Parameter values derived were baseline utility, utility associated with therapies, decrement of infection (per event), utility after clinical intervention (amputation), and decrement of utility related to other adverse events (Table 2).

^{*}a measure that represents preference based valuation of quality of life in a particular health state.

Table 1: Clinical effectiveness data input parameter values in the base case analysis

Debridement Therapy	Biosurgical LDT		Mechanical Ultrasound		Autolytic				Surgical		Sharp		Hydrosurgical	
					Hydrogel		Honey							
Parameter	Value	Data source	Value	Data source	Value	Data source	Value	Data source	Value	Data source	Value	Data source	Value	Data source
Number of treatments conducted	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.91	Granick et al (2006)	2	Assumption based on Granick et al (2006)	1.2	1.18 from Granick et al (2006) and 1.4 from Mosti et al (2005)
Probability of debridement	76.70%	Bagged larvae; Dumville et al (2009)	60.00%	Assumption based on other data and expert opinion	63.20%	Dumville et al (2009)	60.00%	Assumption based on other data and expert opinion	95.00%	Expert opinion	95.00%	Expert opinion	95.00%	Granick et al (2006)
Probability of infection per month of treatment	17.50%	Bagged larvae; Dumville et al (2009)	25.00%	Assumption based on other data and expert opinion	26.00%	Dumville et al (2009)	44.40%	Gethin & Cowman (2009)	21.00%	Assumption based on other data	25.00%	Assumption based on other data	25.00%	Assumption based on other data
Probability of treatment related adverse events during treatment	9.60%	Bagged larvae; Dumville et al (2009)	5.35%	Assumption based on other data and expert opinion	7.70%	Dumville et al (2009)	7.70%	Assumption based on other data and expert opinion	5.35%	Caputo et al (2008)	5.35%	Caputo et al (2008)	5.35%	Caputo et al (2008)

RESULTS

As an indicator of value for money, incremental cost effectiveness ratios (ICERs) were calculated based on the difference in costs incurred and benefits provided by LDT compared to the named comparator. In the UK, the commonly accepted norm for a new intervention to be adopted is £20,000 per QALY gained. This is much the same as in other European jurisdictions and we have used this as our benchmark for acceptable cost-effectiveness.

The results for the base case CUA of LDT versus each of the comparator debridement methods are shown in Table 3.

Figure 2 shows that all plots of incremental costs and QALYs estimated for LDT, compared with all alternatives, fall in the lower right quadrant of the cost-effectiveness plane. Thus, LDT appears to be the dominant therapy — ie it is expected to be more effective and less costly than all alternatives considered.

Sensitivity analysis

The limited availability of data and variation in clinical wound care and debridement practice lead to a high degree of uncertainty surrounding the data inputs and assumptions made during the development of the model. The potential consequences of this uncertainty were explored through sensitivity analysis, as follows.

Hydrosurgical therapy

Although surgical-type debridement is typically achieved with approximately two attempts, hydro-surgical therapy was reported in two published studies to require an average of only 1.18 or 1.4 attempts to achieve debridement (Granick, 2006; Caputo, 2008). A fairly conservative estimate of the number of hydrosurgical procedures conducted (1.2) was taken in the base case. Varying the number of hydrosurgical procedures (n=1.18, 1.4, 1.9) had little impact on the incremental results and none on the overall cost-effectiveness conclusions.

Clinical (terminating) interventions

The rates of clinical intervention (amputation) over time could not be identified in the literature and are subject to uncertainty as a result. Based on the higher rates of amputation reported for autolytic therapies (Ribu et al, 2008), the base case assumes higher rates of clinical intervention over time for hydrogel and honey compared to other initial therapies. To test the consequences of uncertainty around these assumptions, two scenario analyses were conducted. Firstly, a more gradual increase of clinical intervention was applied over time, escalating to the assumption of clinical intervention for all un-debrided wounds at the end of six months; and secondly, the same rates were assumed across all therapies (including autolytic).

Table 2: Cost and health related utility data input parameter values in the base case analysis

Costs			Health utilities		
Parameter	Value	Data source(s)	Parameter	Value	Data source
Cost of therapy (per month or procedure)			Health utility associated with therapy		
LDT	£571.31	Soares et al (2009), Hall et al (2010)	LDT	0.562	Soares et al (2009), Dumville et al (2009)
Mechanical – Ultrasound	£190.95	Watson et al (2011)	Mechanical - Ultrasound	0.515	Watson et al (2011)
Autolytic – Hydrogel	£246.67	Dumville et al (2009)	Autolytic – Hydrogel	0.559	Dumville et al (2009)
Autolytic – Honey	£250	Expert opinion	Autolytic – Honey	0.55	Assumption (expert opinion)
Surgical	£2,320	NHS Reference costs 2010/11	Surgical	0.55	Assumption (expert opinion/other therapy values)
Sharp	£1,370	NHS Reference costs 2010/11	Sharp	0.55	Assumption (expert opinion/other therapy values)
Hydrosurgical	£2,620	Granick et al (2006) (converted to GBP)	Hydrosurgical	0.55	Assumption (expert opinion/other therapy values)
Infection	£621	NHS Reference costs 2010/11*	Baseline utility value of uninfected wound	0.6	Iglesias et al (2004)
Clinical intervention	£6,508	NHS reference costs 2010/11: weighted cost of amputation with/ out major cc (40%) and foot procedures (60%) according to Ribu et al (2008)	Decrement of infection (per event)	0.007	Nelson et al (2006)
Adverse events	£36	GP visit PSSRU Unit Costs 2011**	After clinical intervention	0.54	Nelson et al (2006); relating to amputation

*Department of Health. NHS Reference costs 2010/11. http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_131140 Accessed October 2012

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Table 3: Base case incremental results of LDT compared to alternative debridement therapies			
Debridement comparison made with LDT	Incremental cost	Incremental QALYs	ICER
vs. surgical	-£3,373	0.0015	Dominant
vs. sharp	-£1,638	0.0020	Dominant
vs. hydrosurgical	-£2,268	0.0008	Dominant
vs. mechanical (ultrasound)	-£45	0.0055	Dominant
vs. hydrogel	-£26	0.0009	Dominant
vs. honey	-£176	0.0008	Dominant

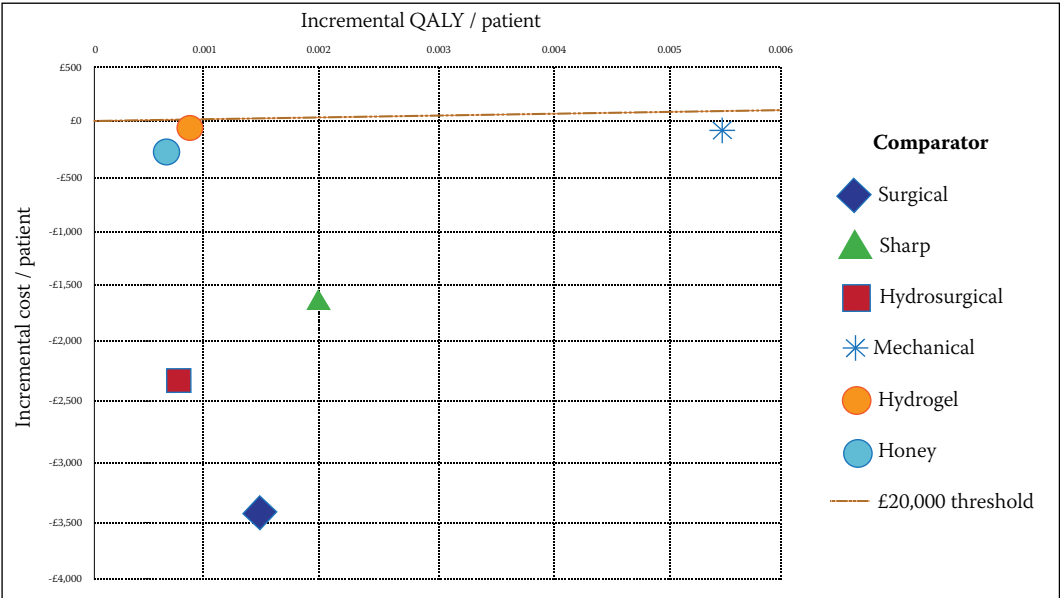


Figure 2: Graphical representation of base case results of LDT compared to alternative debridement therapies on the cost-effectiveness plane.

Increasing the rate of clinical intervention over time for undebrided wounds across all therapies (month 1 to 5: 1%, 2%, 10%, 25% and 50% for honey/hydrogel; 0.5%, 1%, 5%, 10%, and 25% for all other therapies) made little difference to the incremental results and no difference to the cost-effectiveness conclusions of the base case. When the same rates were assumed across all therapies (month 1 to 5: 0.5%, 1%, 5%, 10% and 25% for all other therapies), LDT was no longer dominant compared to hydrogel.

Although estimated to provide higher QALYs in these scenarios, LDT was predicted to be more expensive compared to hydrogel. Nevertheless, with an ICER of £14,802 per QALY gained, LDT would still be considered to be cost-effective at a threshold of £20,000 per QALY.

Infection and adverse event rates

Scenarios were tested in which the infection rate associated with surgical-type therapies was applied per month of treatment, rather than per procedure as in the base case; however, these rates were not found to be drivers of results. Due to the relatively low incidence of adverse events associated with debridement therapies, and their low cost and utility consequences, adverse events were not found to be a driver of results.

Other sensitivity analysis

A range of further sensitivity analyses were conducted as presented in Table 4. Figure 3 presents the results of the sensitivity analysis in the form of tornado plots for mechanical, hydrogel and honey — the debridement methods closest to LDT in the base

case results — and also for surgical debridement. The cost of LDT and the probability of its success in achieving debridement were found to be the key cost drivers, while the utilities associated with LDT and its comparator were key drivers of accumulated benefits.

DISCUSSION

This is the first attempt we are aware of to estimate the cost-effectiveness of multiple options for debridement against a common comparator — LDT. Under the majority of scenarios modelled, LDT was estimated to be a cost-effective therapy for wound debridement. The base case results suggest that initiating treatment with LDT may be a dominant intervention compared

to hydrogel, honey, mechanical, surgical, sharp, and hydrosurgical debridement methods. That is, adopting the use of LDT may result in both cost savings and greater benefits for a patient over one year.

All debridement methods appear to be similar in terms of overall quality of life impact for patients, partially attributable to the assumed practice of changes in treatment for undebrided wounds; however, there appears to be a meaningful estimated difference in costs between treatments. LDT is estimated to be cost saving compared to surgical-type therapies in the base case analysis and also the majority of sensitivity analyses performed. The costs accumulated over one year were more closely

Table 4: Results of univariate sensitivity analyses

Variable changed	LDT vs. surgical	LDT vs. sharp	LDT vs. hydrosurgical	LDT vs. mechanical	LDT vs. hydrogel	LDT vs. honey
Rates						
Probability of debridement with LDT (69% to 84%) [^]	Dominant	Dominant	Dominant	£29,307/ QALY	£358,373/ QALY	£43,564/ QALY
				Dominant	Dominant	Dominant
Probability of infection [°] (+/- 10% of mean)	Dominant	Dominant	Dominant	Dominant	Dominant	Dominant
Probability of AEs [°] (+/- 10% of mean)	Dominant	Dominant	Dominant	Dominant	Dominant	Dominant
Costs						
LDT cost per bag (£195 to £295)	Dominant	Dominant	Dominant	Dominant	Dominant	Dominant
			C-E		Dominated	
Clinical intervention* (£3,174 to £12,418.50)	Dominant	Dominant	Dominant	Dominant	£20,182/ QALY	Dominant
					Dominant	
Infection** (£1,268)	Dominant	Dominant	Dominant	Dominant	Dominant	Dominant
All costs (+/- 10% of mean)	Dominant	Dominant	Dominant	Dominant	Dominant	Dominant
Utilities						
Baseline utility (+/- 5% of mean)	Dominant	Dominant	C-E	Dominant	Dominant	Dominant
			Dominant			
During LDT therapy (+/- 10% of mean)	Dominant	Dominant	Dominant	Dominant	Dominant	Dominant
	C-E	C-E	C-E		£7,214/QALY	C-E
During comparator therapy [only] ^{^^}	C-E	C-E	C-E	Dominant	£16,061/ QALY	C-E
	Dominant	Dominant	Dominant		Dominant	Dominant
*across all therapies, ^ up/down 10% of base case value, **all toe amputation versus all leg amputation, **NHS reference costs with CC (base case used cost without CC) ^^bounds of 95% CI tested if available, else ± 10% of base case value capped at baseline. 10% lead to greater extremes than those CIs available. C-E: cost-effective at threshold of £20,000/QALY						

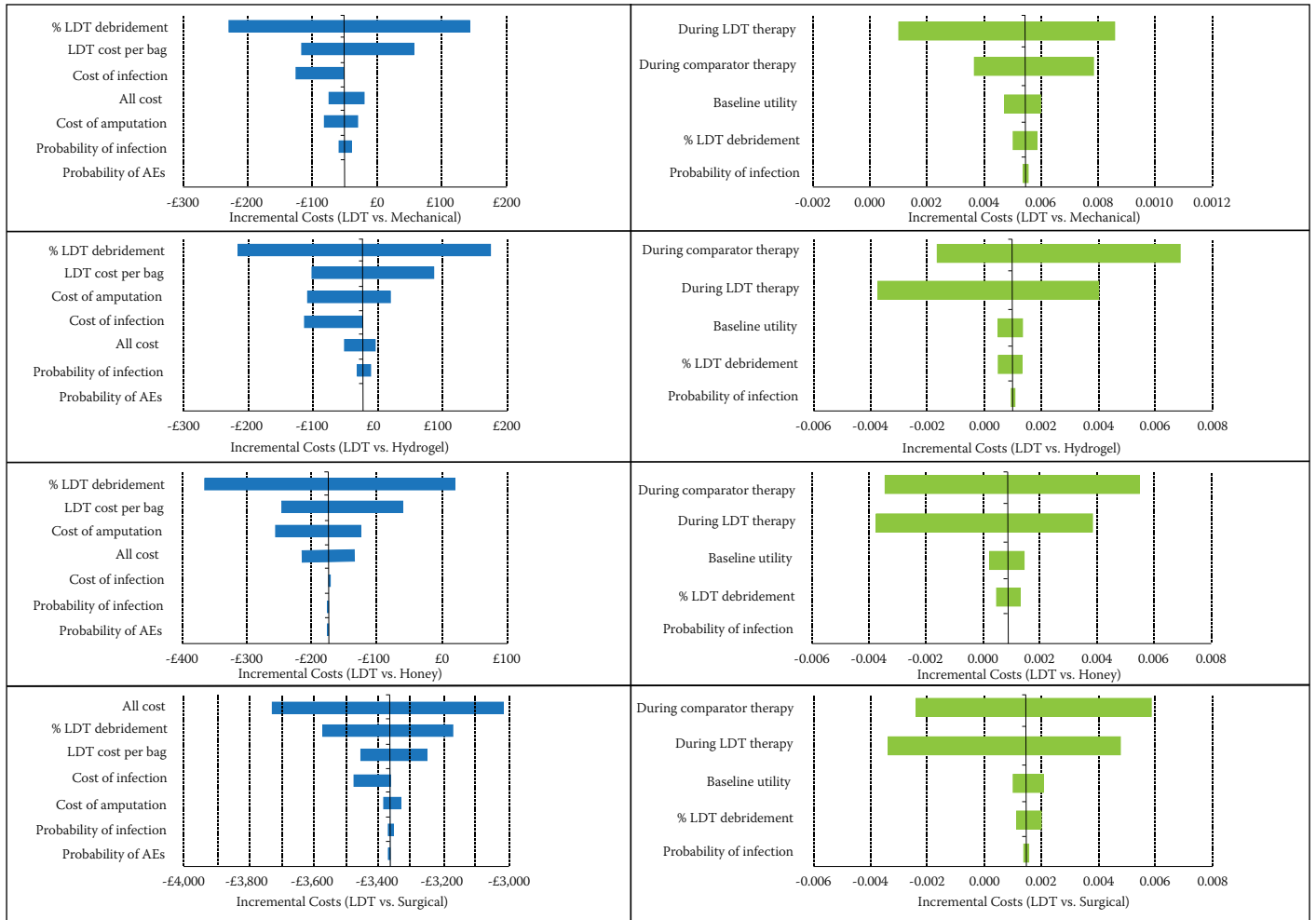


Figure 3: Tornado plots — sensitivity analyses for LDT vs. mechanical, hydrogel, honey and surgical debridement therapies. AE = adverse event.

comparable when initiating treatment with LDT and the other non-surgical therapies; however, LDT was estimated to be cost saving in the base case and in many cases tested in sensitivity analyses.

To address the uncertainty around our results, we undertook a sensitivity analysis, which highlights the parameter inputs that are most influential for overall costs and outcomes. It is particularly important to have strong evidence for the chosen values of these influential parameters. The sensitivity analysis conducted showed that the cost of LDT and the probability of its success in achieving debridement were the key cost drivers, while the utility values associated with the debridement interventions were key drivers of accumulated benefits, emphasising the importance of robust quality of life evidence in this area. The cost of treatment was a significant driver for

surgical therapies due to their higher cost compared to the other debridement therapies considered.

In undertaking this research we faced a number of challenges relating to the variation in wound presentation and care in clinical practice and the lack of comparative data based on good quality RCTs of the available interventions. Despite the heterogeneity of patients, complexity of debridement approaches and variation in wound care pathways observed in clinical practice, the model developed for this analysis was necessarily simple. In reality, treatment may be tailored to the type of wound presented and its progression; in such cases, changes in debridement therapy may happen over different time intervals and some debridement methods more frequently follow others. For example, one debridement method may be used for a short time to rid the wound of most sloughy tissue

(surgical) or soften hard eschar (autolytic), followed by another debridement therapy, such as LDT, for a longer period of time. Our simple model gives an overall picture of the comparative cost-effectiveness of therapies in circumstances where any of the available debridement methods would be clinically appropriate.

An additional issue is that published data available in this area is limited, which alters both the level of complexity that can be accommodated in modelling and the reliability of any results modelling can provide. The consequent reliance on expert opinion to inform data inputs and modelling assumptions is a major limitation of the modelling described here.

Further limitations as a result of data paucity include possible issues concerning consistency of studies from which parameter values were derived, choice of modelled endpoint and type of wound modelled. The primary endpoint modelled was wound debridement; however, modelling the treatment of wounds until healing, including any recurrences, would be superior. No distinction could be made between wound types, despite known differences between diabetic foot or venous leg ulcers.

The described data limitations and structural assumptions lead to great uncertainty in the modelling results; however, it was difficult to quantify the impact of this uncertainty through probabilistic sensitivity analysis due to the paucity of data to support the specification of sampling distributions and reasonable ranges for parameter values. Full probabilistic sensitivity analysis is strongly recommended should sufficient data become available in the future.

CONCLUSIONS

Despite its limitations the model provides useful information regarding the cost-effectiveness of LDT and important insights for both healthcare professionals and budget holders regarding the influential factors associated with treatment that determine the cost-effectiveness of debridement therapy.

The modelling process has enabled the identification and specification of gaps in available evidence relating to wound debridement. Our findings suggest that undertaking further research to improve this evidence base, particularly in the areas of quality of life and resource use associated with therapies, is of great importance if the costs and effects of wound

debridement are to be better understood and to support evidence-based decision making.

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Evidence for larval debridement therapy in wound cleansing and healing

Larvae of the medicinal maggot (*Lucilia sericata*) are now used worldwide to treat and manage chronic wounds, such as leg ulcers, pressure ulcers, diabetic foot ulcers, as well as for infected surgical wounds, burns and trauma injuries. Clinical evidence suggests that larval debridement therapy (LDT) has the following beneficial effects on a wound: debridement, cleansing and enhanced healing. Scientific studies reveal some of the mechanisms behind larval action: larval enzymes are responsible for breaking down and removing necrotic tissue in the wound bed; antibacterial factors present in secretions inhibit wound bacteria and disrupt biofilm; and distinct compounds within secretions appear to promote important physiological processes involved in wound healing, such as fibroblast migration and angiogenesis. This article summarises the most recent scientific evidence, which seeks to explain the actions of LDT in chronic and infected wounds.

KEY WORDS

- ▶▶ Larval therapy
- ▶▶ Debridement
- ▶▶ Biofilm
- ▶▶ Wound healing

ROLE OF LDT IN WOUND DEBRIDEMENT

Of all the actions associated with LDT, tissue debridement is the best understood. Verified by copious clinical studies (Sherman, 2003; Chan et al, 2007; Tantawi et al, 2007; Gilead et al, 2012), randomised controlled trials (RCTs) (Dumville et al, 2009; Opletalová et al, 2012), and rigorous scientific evidence (Chambers et al, 2003; Telford et al, 2010; Britland et al, 2011), it is widely acknowledged that larvae can selectively dissolve necrotic tissue. Deep tissue debridement is also possible because larvae are able to access 'nooks and crannies' of wounds (Zumpt 1965), and may lead to more rapid debris removal rates compared to many other non-surgical treatments (Whitaker et al, 2007).

The largest component of normal skin is the extracellular matrix (ECM), which acts as a structural scaffold for cells. The breakdown of ECM components of a wound by proteolytic enzymes is an intrinsic part of the initial stages of tissue repair (Gailit and Clark, 1994). Larvae have been shown to secrete a mixture of enzymes (Figure 1) including chymotrypsin and trypsin-like, aspartyl and metalloproteinases (Chambers et al, 2003), which break down fibrin clots and necrotic tissue, and promote the reorganisation and modification of ECM (Horobin et al, 2006). Larvae provide their own optimal conditions for serine

and metalloproteinases to act within the wound and they secrete ammonia to increase the pH in the wound bed to activate trypsin-like proteases.

Proteolytic enzymes, such as chymotrypsin, have been shown to be the key agents responsible for the debriding action of larvae. Recently, researchers have produced a recombinant chymotrypsin I, with very potent enzymatic activity (Telford et al, 2010). A study involving patients with venous leg ulcers showed how this active recombinant enzyme improved eschar breakdown in these wounds compared to that seen with human and bovine chymotrypsins (Telford et al, 2010).

Although its role in wound debridement is unequivocally established, chymotrypsin present in larval secretions has also recently been identified as an influential molecule in preventing the adherence of pathogenic bacteria to potential colonisation sites in the wound bed, as well as being important in the formation and disruption of wound biofilm.

ROLE OF LDT IN INFECTION CONTROL/ BIOFILM MANAGEMENT

Antibacterial effects of larval secretions

The ability of larvae to combat wound infections has been widely reported. This may be simply due to rapid debridement or ingestion and subsequent destruction of wound pathogens as larvae feed (Mumcuoglu et al, 2001; Daeschlein et al, 2007). Nonetheless, researchers



Figure 1: Larvae of *Lucilia sericata*, secreting enzymes as they feed.

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KEY POINTS

- ▶ LDT can be used for the rapid removal of necrotic and non-viable tissue in the wound bed.
- ▶ Larval secretions contain effective antibacterial agents with potent activity against Gram-negative and -positive bacteria.
- ▶ LDT has been shown to interfere with bacterial biofilm formation and establishment.
- ▶ LDT secretions may help to stimulate physiological processes involved in wound healing.

have long been convinced that larval secretions also contain effective antibacterial agents (Simmons, 1935a,b; Pavillard and Wright, 1957). Subsequently, recent studies have provided profound evidence of the presence of antibacterial factors within larval secretions (Bexfield et al, 2004; Kerridge et al, 2005; Barnes et al, 2010), confirming potent activity against both Gram-positive and Gram-negative bacteria (Huberman et al, 2007; Jaklic et al, 2008).

Several recent studies have shed new light on the actual nature of these antibacterial factors. For example, a large (high molecular weight) peptide, Lucifensin, has been purified from larval secretions and various tissues (Cerevosky et al, 2010). Lucifensin has been shown to be potently active against several bacteria including *S. pyogenes* and *S. pneumoniae* (Andersen et al, 2010). Additionally, fractions collected from sterile larval secretions (Figure 2), showed powerful activity against 12 out of 15 tested clinical isolates of methicillin-resistant *S. aureus* (MRSA) (Figure 3), as well as a range of other isolated pathogens (Bexfield et al, 2008). Moreover, the mass and empirical formula of a small, low molecular weight antibacterial agent present in these fractions has been accurately determined, and registered as a new, novel antibiotic, Seraticin® (Nigam et al, 2010).

A further investigation on antibacterial activities of compounds released externally by the larvae has confirmed the presence of a range of structurally diverse compounds (Kruglikova and Chernysh, 2011), and most recently, research scientists in China have reported the isolation and purification of yet another antibacterial molecule, MAMP, from larval secretions, which has a significant inhibitory effect on *S. aureus* and appears to work by disrupting the bacterial cell membrane (Zhang et al, 2013).

The cumulative scientific evidence outlined above undisputedly suggests the presence of antibacterial activity in larval secretions. How the secretion of these externalised factors manifests clinically, and to what extent it influences wound cleansing, still needs to be thoroughly investigated. To this end, several studies report on the inducible nature of larval antibacterial activity. Huberman et al (2007) reported a three- to six-fold increase in the comparable antibacterial activity in larvae removed from chronic wounds, compared to sterile larvae. Kabawata et al (2010) analysed the influence of pre-incubating sterile larvae in a bacterial

suspension, and subsequently assessed larval extracts for antibacterial activity. The results showed that infected larvae had better antibacterial capacities than sterile larvae. The researchers argue that the clinical wound situation would enable larvae in the infected environment to influence production of antibacterial activities. This discovery suggests that sterile larvae placed in an infected wound are triggered by the presence, or oral ingestion, of surrounding bacteria, and start producing and secreting their antibacterial agents, acting like small, antibiotic-secreting factories.

Anti-biofilm effects of larval secretions

Often, wound bacteria aggregate to form a resistant layer called a biofilm. This is an established community of stable microbial cells that adhere to each other and/or to a surface, and are embedded in a complex self-produced mixture of extracellular polymers. It is generally agreed that wound chronicity is aggravated by the presence of a biofilm.

Wound biofilm is extremely difficult to eradicate; many topical treatments are ineffective, and antibiotics, designed to attack free (planktonic) bacterial cells cannot penetrate this walled community (Davies et al, 2007; Cowan et al, 2013). It has been shown that larval secretions can both disrupt established biofilm and prevent its formation (van der Plas et al, 2008; Harris et al, 2009). Harris and co-workers (2009) considered the effect of larval secretions on the formation and disruption of biofilms from two different strains of *S. epidermidis*, 1457 and 5179-R1, which exhibit different mechanisms of biofilm formation. Both types of biofilm formation were disrupted by the larvae, and it was shown that chymotrypsin, derived from larval secretions, was the responsible molecule. This

Figure 2: Collection of sterile *Lucilia sericata* externalised secretions.

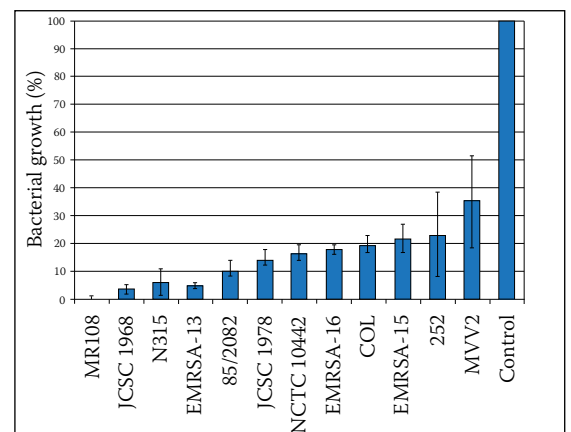


Figure 3: Growth inhibition effect of larval secretions (<500Da fraction) on 12 clinical isolates of MRSA (bacterial susceptibility was assessed using the Turbidometric assay).

detrimental effect on biofilm was observed for both nascent and pre-formed biofilms of *S. epidermidis* 5179-R1 (Harris et al, 2013).

Chymotrypsin has also recently been implicated in the destruction of important molecules in the necrotic wound bed (macromolecules (MSCRAMM), which may act as adherent sites for the colonisation and subsequent infection of pathogenic bacteria (Pritchard and Brown, 2013). By removing these bacterial mooring sites, larvae applied to a wound may help in preventing further wound infections.

Furthermore, it has recently been established that larval secretions contain an enzyme that is able to break down DNA from wound slough (Brown et al 2012). This DNase is also able to digest bacterial DNA — a significant discovery because extracellular DNA is an important requirement for some bacterial species to instigate biofilm formation. If DNase present in larval secretions eliminates this source, this may explain the anti-biofilm effects of larvae and their secretions.

Interestingly, like the antibacterial molecules previously mentioned, larval molecules associated with disruption of biofilm have also been shown to be inducible, eg secretions collected from larvae incubated with bacteria were more able to destroy *P. aeruginosa* biofilm (Jiang et al, 2012)

Other studies have considered the effects of larvae on biofilm production on surfaces commonly used in a medical setting (Cazander et al, 2009; 2010). Larval secretions were found to be able to prevent biofilm formation and disrupt existing biofilms of *P. aeruginosa*; the study, which encompassed many different bacterial species, noted reduced biofilm formations after treatment with larval secretions on polyethylene, titanium and stainless steel surfaces, with a maximal reduction in biofilm formation of 92%. This result may be of great significance, especially when considering peri-prosthetic infections.

Combining larval secretions with existing medical treatments may also possess greater therapeutic potential, and this has been initially investigated with antibiotics. It was shown that combining larval secretions with either vancomycin or daptomycin, increased potency of the antibiotic (van der Plas et al, 2010).

It seems highly probable, therefore, that in a wound, larvae secrete distinct factors that are able to combat wound pathogens and also interfere with bacterial biofilm formation and establishment.

ROLE OF LDT AND EXUDATE MANAGEMENT

Wound exudate is the fluid produced by wounds following haemostasis. The inflammatory response, which is mounted on tissue injury, increases capillary permeability. This lets large, important immune cells out of capillaries and into the wound site and leads to fluid leakage in the vicinity of the wound. Normally, wound exudate is a healthy sign, containing many growth factors and molecules that stimulate the healing process. However, if the wound becomes chronic, the inflammatory phase is prolonged. Excessive exudate, usually consisting of pathogenic bacteria and destructive proteolytic enzymes, may build up and cause a host of problems, including malodour, skin maceration and a delay in healing (Hampton and Collins, 2004).

Since LDT removes dead and damaged tissue, which eases the microbial burden of the wound, it follows that LDT could facilitate the reduction of the inflammatory response. This would in turn stabilise the moisture balance and combat excessive exudation (Schultz et al, 2003). However, contradictory reports suggest that LDT may increase wound exudate (Vuolo, 2004). Thus the role of larvae in managing wound exudate has not yet been unequivocally established.

EFFECT OF LARVAL SECRETIONS ON WOUND HEALING

During wound healing, specialised leukocytes produce a wide variety of immune mediators, growth factors and distinctive cytokines. After removal of necrotic and infected tissue, the wound progresses into the proliferative phase. Granulation occurs and fibroblasts migrate inwards from the wound margins to generate and assemble collagen. Several researchers have shown the positive effects of larval secretions on fibroblasts and other cells involved in facilitating healing (Prete, 1997; van der Plas et al, 2007).

Recently, proteolytic larval secretions were found to induce changes in cell morphologies and to stimulate fibroblast migration in the wound (Horobin et al, 2003). Fibroblasts are stimulated by many chemical activators and messengers, mostly released by macrophages, which dominate the clinical picture towards the end of the inflammatory phase. Fibroblasts secrete a variety of cytokines, allowing other vital cells, eg endothelial cells and angiocytes, to proliferate. Expansion of these cell numbers contributes to the

growth of new blood vessels (angiogenesis), allowing oxygen to reach newly forming tissue.

The effect of larval secretions on inflammatory cells has been studied. Neutrophils, monocytes and macrophages are present in excess in chronic wounds. They produce increased amounts of pro-inflammatory cytokines, proteases, eg elastase, and reactive oxygen species (ROS) such as hydrogen peroxide, and are therefore extremely damaging to the chronic wound environment (Schreml et al, 2010).

Investigations into the effect of larval secretions on neutrophil activity and viability revealed that secretions are capable of inhibiting elastase release and hydrogen peroxide production in activated neutrophils, without compromising neutrophil viability (van der Plas et al, 2007). Also, there was decreased production of pro-inflammatory cytokines and macrophage inflammatory protein, with increased production of anti-inflammatory cytokines (van der Plas et al, 2009a). This research further demonstrates the capacity of larvae to reduce inflammation in a chronic wound.

For wounds to progress to healing and closure, the inward migration of resident epidermal keratinocytes and dermal cells, including dermal microvascular cells, is a crucial step. In a scratch test comparing larval secretions to secretion-free controls, larval secretions were found to significantly induce migration of human microvascular endothelial cells (HMEC1) and the presence of secretions increased wound healing by 30% (Wang et al, 2009). The authors also showed that a key signalling pathway was activated by larval secretions, and this encouraged the endothelial cell migration.

Distinct pro-angiogenic compounds have also been detected within larval secretions, including the amino acids L-histidine, 3-guanidinopropionic acid (GPA) and L-valinol (Bexfield et al, 2009). All three identified compounds, but notably valinol, were found to specifically and significantly enhance the proliferation of human endothelial cells, with no effect observed on fibroblast proliferation. In other research, fatty acids from homogenised larvae have also been shown to enhance angiogenesis of dermal excision wounds via increased protein expression of an angiogenic growth factor, VEGF (vascular endothelial growth factor) (Zhang et al, 2010).

Finally, there is experimental evidence to suggest that larval secretions may exert an effect on another important component of the immune response — the complement system. This complex cascade of

potent proteins is normally systemically activated to crush an invading pathogen attack, so is a necessary accompaniment to a healthy and protective immune state. However, excessive local complement activation around the wound environment can lead to chronic inflammation. Researchers have recently shown that larval secretions suppress complement activity by inhibiting the production of several important complement proteins. They concluded that the ability of larvae to reduce this overactive immune response may play an important role in wound healing (Cazander et al, 2012).

CONCLUSION

The studies outlined above, undertaken in the laboratories of independent scientists, demonstrate a sound scientific basis for the wound debriding, cleansing and healing effects observed during larval therapy. Larval proteolytic enzymes encourage wound debridement, secreted antibacterial factors kill a range of pathogens and are capable of disrupting biofilm. Larvae can steer wound healing by directing it away from a chronic inflammatory response through the attenuation of neutrophils, monocytes and macrophages. Their secretions promote fibroblast migration, while pro-angiogenic activity of secretions actively encourages granulation tissue formation.

In the last decade, research scientists have avidly raised their game — revealing the presence of distinct bio-active molecules produced by larvae. This has led to a much better understanding of the scientific mechanisms that underlie the actions clinically observed in the wounds with the presence of larvae. Clearly, the action of larvae in wounds is multifaceted and, undoubtedly, further research will reveal yet more fascinating interactions between the molecules they produce and the promotion of a healthy wound bed.

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Setting up a LDT service: lessons learnt from Blackpool

KEY WORDS

- ▶ Service provision
- ▶ Multidisciplinary team
- ▶ Changing practice

A larval debridement service at the Blackpool Teaching Hospitals was set up in 2011 to extend the debridement options for patients attending the vascular outpatient clinic. A treatment protocol was implemented to facilitate larval debridement therapy (LDT) and this was subsequently adapted to involve the community teams working in the Blackpool area. Two years on, LDT is now an established debridement method with good integration between the hospital and community teams delivering the service.

INTRODUCING A LDT SERVICE

Larval debridement therapy (LDT) was introduced by the vascular team at the Blackpool Teaching Hospitals in September 2011. The initial intention was to target patients who were unfit for surgical intervention, but would benefit from a lower-risk debridement option. This was subsequently expanded to include patients who met the criteria for surgical debridement, but for whom LDT was seen as a cheaper, but equally effective, treatment.

A protocol was agreed that allowed efficient and timely delivery of LDT with measurement and ordering of larvae by the staff within the surgical assessment unit (SAU).

This treatment protocol involved the following referral and treatment steps:

- ▶ Patient was assessed by the vascular consultant in the outpatient clinic. If the criteria for LDT were met and the patient consented to treatment, they would be referred to SAU for wound measurement and ordering of the larvae
- ▶ Patient was seen next day in SAU for application of the larvae. Patient information on LDT was provided to improve concordance with treatment and the patient given a carrier bag with appropriate outer dressings to take home
- ▶ Patient was seen by the district nurses for daily wound care (eg to check/change outer dressing) in accordance with manufacturer's recommendations
- ▶ Patient was seen after four days in the vascular clinic for review and/or reapplication of LDT.

A key goal in setting up this service was to minimise the need for a hospital stay, helping to reduce costs and benefiting patients. However, problems due to lack of

an appropriate treatment space in the SAU due to changes within the hospital, meant an alternative pathway was needed with greater involvement of the community teams.

This led to the current system in which the patients are referred by the vascular team to the hospital trust's tissue viability nurse (TVN) advisor. After assessment in the outpatient vascular clinic, a patient's details are sent by letter/email to the TVN advisor, which are then communicated to the appropriate community team. Advice on measurement and ordering of larvae is given via telephone or by visit from the TVN advisor for more complex wounds. This protocol is now well-established with the TVN advisor acting as a coordinator for LDT.

The development of the LDT service has required good communication between the hospital and community teams to ensure effective coordination of personnel and timely ordering/application and removal of larvae. In addition, education of GPs and district nurses has been important in expanding this service to the community with training and support provided on application and removal of the larvae.

The use of LDT on surgical wards has also been encouraged within the hospital. Again, this was initially targeted at patients who required wound debridement but were not fit for surgery. Concerns among healthcare staff with regards to the use of larval therapy, largely due to the 'yuck' factor, had meant that LDT was not established as a method of debridement. Larval therapy was also seen as a complicated technique to perform. However, education and support of link nurses has led to greater acceptance of the therapy and uptake on wards, including orthopaedics, where LDT is used

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for patients with non-healing chronic wounds or large haematomas. With greater awareness, has come increased confidence in using LDT, with areas more likely to discuss cases with the TVN advisor and be proactive in prescribing LDT.

To help overcome initial procurement issues, prescribing procedures within the hospital have been simplified, with all prescriptions now authorised on a named patient basis by the vascular surgeon using a standard form and verified by the hospital pharmacist. This has improved the ordering process, with more timely application of larvae and the ability to document overall usage within the hospital.

Over the past 16 months (April 2012 to August 2013), there have been a total of 29 prescriptions for LDT in the community (Blackpool and North Lancashire) with an average of 1.8 prescriptions per

month. Prescribing data from the hospital show that there have been 24 prescriptions for LDT between September 2012 and July 2013, with an average of 1.625 prescriptions per patient.

Making the case for LDT

In establishing the LDT service, it has been important to highlight the benefits of using LDT on patients with wounds. In particular, the ability of LDT to debride wounds rapidly, minimise the need for anaesthesia and reduce antibiotic use in vulnerable patients. Although there is an initial cost outlay in using LDT, the fact that patients can be treated at home, have few complications and good outcomes, often with a single application, has meant that LDT is now no longer used as a last resort, but as a proactive choice to clean and close the wound quickly.

CASE STUDIES USING LDT FROM BLACKPOOL TEACHING HOSPITALS

Case study 1

Mrs M was admitted for amputation of her infected diabetic foot. Silver dressings and antibiotics were prescribed, but the wound site deteriorated and she underwent a below-knee amputation. Despite further antibiotic use and application of silver dressings, the amputation site broke down. It was decided to start LDT and discontinue antibiotic therapy. On removal of the larvae at four days, the wound bed looked healthier and a second application was applied. Mrs M was very emotional and had been reluctant to have the below-knee amputation. She was happy to receive LDT, especially as it meant that she did not have to return to theatre for further surgery.

Case study 2

A 38-year-old woman with a long history of intravenous drug abuse and deep and superficial venous insufficiency, presented with infected venous leg ulcers on both legs (Figures 1 and 2). The ulcers had been present for over 10 years and were very painful, mainly due to chronic infection.

The patient had a poor concordance record in the hospital and in the community. She was on methadone but was still making regular use of illegal substances. She failed to attend the leg ulcer clinic on several occasions. She had no peripheral intravenous access in both legs and arms and clinicians were reluctant to put in a central intravenous access for antibiotics and anaesthetic induction because of poor patient behaviour — on more than one occasion the patient was thought to have left the ward and used the intravenous access provided by the hospital to inject drugs systemically. LDT was selected to clean her ulcers. After four days of therapy in hospital, plus leg elevation, the ulcers had improved and surgical debridement was not deemed necessary (Figures 3 and 4). The patient was discharged and treated with compression therapy in the community.



Figure 1



Figure 2



Figure 3



Figure 4

KEY POINTS

- ▶ A LDT service was set up to complement existing methods of debridement.
- ▶ Although initially a hospital-based service, this service was extended to involve community team.
- ▶ Education and training were provided to support nurses using LDT.
- ▶ A clinical evaluation is currently in progress to look at optimising the service and assess which patients benefit most from LDT.

Securing the service

The LDT service in Blackpool offers an example of an integrated service where patients have good access to LDT. Referral pathways are known, and non-specialists working in the community have a good knowledge of the support networks available to them in the hospital. In a recent consensus, this was considered a key component of an ideal debridement service (see Box 1) (Wounds UK, 2013).

Box 1: Components of an ideal debridement service (Wounds UK, 2013)

- ▶ Integrated services (primary and secondary care) so that patients/practitioners are able to access all methods of debridement where appropriate
- ▶ Patient information/leaflets to facilitate patient understanding of debridement and choice of techniques recommended by staff
- ▶ Confident practitioners who are knowledgeable about all debridement methods, decision-making and referral pathways
- ▶ Clear roles to ensure interventions are carried out by the most appropriate practitioner, providing the most efficient care
- ▶ Pathways of care with expected time frames for patients to receive treatment
- ▶ Clear, concise evidence-based clinical guidelines across community and acute services
- ▶ Rolling programme of relevant education and training with clear guidelines for non-specialists on how to access education and training
- ▶ Audits to measure outcomes
- ▶ Access to clinical photography and diagnostic services
- ▶ MDT support where required

Increasingly, questions are raised around cost and cost-effectiveness of advanced wound care treatments (Wounds International, 2013). Within the service at Blackpool, the decision to prescribe LDT is not made solely on cost, but on safety of method (low risk) and time (eg compared to autolytic debridement, which is often seen as the low-cost first choice) (Wounds UK, 2013). However, whether an intervention provides high value depends on assessing whether its health benefits justify its costs. Plans are therefore underway for a clinical case series evaluation of LDT, led by the vascular team, to document outcomes using medical photography, clinical data collection and follow-up. This will help to quantify the potential for LDT to reduce overall costs and help confirm the benefits of using LDT in different patient groups.

Encouraging the use of LDT for patients at home where possible has obvious cost savings. Working closely with the district nurses and GPs has led to a well-established service with good uptake of LDT in the community. Education on the use of LDT via the TVN advisor based at Blackpool Teaching Hospitals and training via company-based clinical nurse specialists, has been important in supporting these teams. This has led to the development of a policy document for district nurses on using larval therapy, which is being incorporated into the wound management pathway. This can be used along with existing guidelines on the use of LDT (for example: AWTVN, 2013).

Removing organisational barriers to debridement

The recent organisational changes within the NHS in Blackpool have brought together three different trusts, each with their own formulary. Providing consistent education and support to those working across, what is now a wider demographic area, is even more important to ensure clear rationales for prescribing. As many patients will be seen initially by practitioners working in the community, their actions and decisions about when to debride and which method to choose are key to wound progression (Wounds UK, 2013). In a recent study (Wilcox et al, 2013), researchers found that chronic wounds typically healed faster with more frequent debridement, confirming it as an integral part of caring for a patient with a wound. For optimal care, those working in acute and community care need to be supported by education to ensure they can recognise when debridement is required, know what options are open to them and receive training to ensure they have the necessary skills for debridement (Challinor, 2012). In Blackpool, improving access to resources and training has increased patient choice, with more responsive and safe care through timely referrals, ultimately helping to improve patient outcomes.

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Reflections on changing practice

There have been many published works to support the use of larval debridement therapy (LDT) *in-vitro* (see pages 12–16). However, laboratory findings need to be interpreted and translated into clinical practice by clinicians using the therapy.

As two tissue viability nurse specialists working in an acute hospital in Kent, we decided to evaluate the use of larvae in the debridement of haematomas based on the principles of wound bed preparation.

A haematoma is frequently sustained as the result of an injury/trauma and patients often have been in hospital for several days and seen by various medical and surgical teams.

In the past, LDT has been only used for these patients if other modalities were not available or when the patient was deemed unsuitable for surgical debridement. This often meant that referral to the tissue viability team for assessment and suitability of LDT was delayed; early referral

would allow prompt implementation of LDT. It was therefore agreed that all patients with a haematoma would be referred to the team as soon as possible after admission, and the TVN would assess and discuss the suitability for LDT with the consultant team, providing a surgical debridement procedure was not already planned.

The cases detailed below are three of the approximately 20 patients with haematoma treated with LDT over the past three years. All patients had rapid debridement compared with conventional treatments (eg hydrogels), some with one application and some with two or more treatments. After LDT, all wounds were clean and granulating, facilitating the use of conventional dressings or negative pressure wound therapy to close the wound. Rapid debridement reduced the length of stay by approximately 7–10 days. This had a beneficial effect, resulting in greater patient wellbeing and staff satisfaction.

CASE 1: HAEMATOMA TO LEFT LEG



Figure 1: Patient with idiopathic thrombocytopenia suffered haematoma after a fall and injury to left leg. The blood blister was incised conservatively to allow easy access for application of free-range larvae (600). There were concerns about potential bleeding and it was agreed to keep the patient in hospital for close observation during therapy.



Figure 2: Larvae were removed two days later (earlier than expected) as the patient had experienced some increased pain in the leg, which was not fully relieved by analgesics. A BioBag was applied to contain the larvae and reduce discomfort/pain.



Figure 3: Partial debridement was seen after four days and a second BioBag was applied. There was some excoriation of the surrounding skin due to larval secretions. This can be avoided using a skin barrier product.



Figure 4: Patient was discharged home with Hydrofiber® dressings for follow-up by the district nurse.

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CASE 2: HAEMATOMA TO LEFT FOREARM



Figure 1: Injury to the left arm caused by a hoist sling 'rubbing' and 'bruising' the skin and tissues. The patient was seen by the TVN and larvae ordered.



Figure 2: Hydrocolloid dressing applied to the surrounding skin to protect periwound skin and contain the free-range larvae.



Figure 3: Larvae were removed three days later.



Figure 4: Larvae (600) were applied for four days. After removal, wound bed comprised 100% granulation tissue.

CASE 3: HAEMATOMA TO RIGHT LEG



Figure 1 (left and below): The patient presented with a very swollen and tender leg. Second opinion was sought due to concern about fragility of surrounding skin and tissues and to avoid further damage during the application of larvae.



Figure 2: A BioBag of larvae was applied over the haematoma. This was deemed a safer option, reducing potential complications associated with free-range larvae.



Figure 3: Partial debridement was seen four days later. Due to improvement in the condition of the surrounding skin, the decision was made to apply free-range larvae.



Figure 4: Good debridement was achieved following free-range application and only superficial slough remained. Patient was discharged with Hydrofiber® dressings for district nurse follow-up. The patient was referred to the plastics team, but deemed unsuitable for surgery due to advanced age and comorbidities.



Figure 5: The patient later presented for an unrelated problem and TVNs were able to see the fully healed area.

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