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Skin sepsis in meat handlers: observations on the causes of injury with special reference to bone

By M. BARNHAM and J. KERBY

Department of Microbiology, Harrogate General Hospital, Knaresborough Road, Harrogate, North Yorkshire HG2 7ND

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SUMMARY

Outbreaks of wound infection with *Streptococcus pyogenes* and *Staphylococcus aureus* occurred in an abattoir and a pork-processing factory in Autumn 1980. Investigations showed that staff handling the meat before de-boning were particularly affected and that bone was the cause of 48% of the wounds which became clinically infected. Of the total isolates of *Strep. pyogenes* and *Staph. aureus* from wounds of known cause 75% were from lesions caused by bone. In one outbreak streptococcal infection was seen principally in newly-employed staff. Group L streptococci were found in several sites in the pork factory and were isolated from infected lesions in two workers. *Strep. pyogenes* and *Staph. aureus* were cultured from tap handles in the lavatories.

Sixty-six workers were examined in a non-epidemic period and 59% were found to have current wounds on the hand or wrist; 13% of wounds were infected but *Strep. pyogenes* was not isolated. Bone was the commonest of the many causes of injury, accounting for 31% of all wounds. Butchers had the highest rates of wounding and most bone-inflicted injury was seen in this group. Packers were the only group to wear protective gloves regularly. Damaged fingernails were found in 50% of workers, including a high proportion of nail-biters (33% of all workers). The epidemic strain of *Staph. aureus* was cultured from bitten fingernails. Three of four infected workers carrying epidemic organisms in the throat were examined and all were nail-biters. Sharp-edged bone was produced by rotary saws early in the production line and bone dust contaminated the carcasses and adjacent surfaces. It is suggested that bone fragments could contaminate wounds and that this might have implications for the initiation of infection and the development of outbreaks.

INTRODUCTION

In the nature of their work meat handlers are subject to various infections of the skin including orf, erysipeloid, anthrax, tuberculosis and streptococcal sepsis (Hunter, 1978; Fraser *et al.* 1979). Zoonoses such as orf and erysipeloid can be contracted by the handlers from infected animal carcasses. There is no evidence that carcasses are the source of the strains of *Strep. pyogenes* causing infection in handlers and, indeed, isolation of this organism from animals is very unusual (Lancefield, 1972). It seems likely that *Strep. pyogenes* spreads directly or indirectly from man to man under favourable conditions at work.

In two Health Districts in North Yorkshire we recently detected outbreaks of mixed staphylococcal and streptococcal skin sepsis in workers at an abattoir (Firm A) and a pork-processing factory (Firm B). We studied the causes of the wounds which had become infected and we later returned at a non-epidemic period to determine the general prevalence and causes of wounds, and to examine the sharp bones which often cause injury. We present here the findings of these studies and discuss the possible relevance of bone to wound infection in meat handlers.

BACTERIOLOGICAL METHODS

Plain cotton swabs (Transwabs: Medical Wire and Equipment Co.) were used to swab lesions, nose, throat or environment and sent to the laboratory without delay in the accompanying plastic sheaths containing Amies clear transport medium. Non-selective horse blood agar plates (Gibco no. 2) were inoculated and incubated at 37 °C for 24 h aerobically and anaerobically. Purified cultures of *Staph. aureus* were identified by coagulase reaction and antibiotic susceptibility patterns were assessed by disc diffusion (Stokes, 1975); isolates were phage-typed at the Leeds Public Health Laboratory. Beta-haemolytic streptococci were similarly tested for antibiotic susceptibility and grouped by a coagglutination technique (Phadebact Streptococcus Test: Pharmacia Diagnostics). Isolates of groups other than A, B, C, D and G were grouped and *Strep. pyogenes* typed for M and T antigens and Opacity Factor (OF) reaction by the Streptococcus Reference Unit, Division of Hospital Infection, Central Public Health Laboratory, Colindale.

OUTBREAKS, INVESTIGATIONS AND RESULTS

Outbreak at Firm A

At an abattoir with an establishment of 21 workers 250 sheep, 70 pigs and 40 cattle are slaughtered weekly. New buildings for cutting up and packing meat on the site were opened in September 1980 and within a month skin infection was occurring in the workers, with a peak of infection at the end of October. Details of the staffing establishment, the groups of workers affected and the bacteriological findings in early November are given in Tables 1 and 2. Workers are grouped into categories of butchers (mostly men), packers (mostly women) and others according to the nature of their work. More than half of the workers were affected, particularly the butchers, and the predominant lesions were infected cuts caused by bones on the hands and arms. Ascending lymphangitis occurred in three workers and the severity caused one of them to give up work. One butcher, not shown in the Table, had a lesion of orf on a finger.

Bacteriological studies revealed tetracycline-resistant *Strep. pyogenes* T-type 3/13/B3264, M-type 33 in three wounds and the strain was carried by three others in the nose or throat. One carrier had been employed by the firm for 5 years but five out of six workers with proven or clinical streptococcal infection and another carrier had been employed for less than 6 weeks. The average length of employment in the abattoir was 16 months. *Strep. pyogenes* of the same type was isolated from taps in the women's lavatory. *Staph. aureus*, mainly penicillin-resistant phage type 85 but some penicillin-sensitive type 52A/79, was isolated from six wounds, a

Table 1. *Distribution of infection among categories of workers in autumn outbreaks at Firms A and B*

Firm	Category	Job description	No. employed	No. affected in outbreak
A	Butchers	Slaughter	4	2 (50)*
		Butcher	6	5 (83)
		Meat Inspector	1	1
		Total	11	8 (73)
	Packers	Packing	8	3 (38)
	Others	Managers	2	0
	Totals		21	11 (52)
B	Butchers	Butcher/Slaughter	15	4 (27)
		Supervisor/Inspector	8	—
		Gut	2	—
		Brine Cellar	5	2 (40)
		Boning	7	1
		Total	37	7 (19)
	Packers	Sausage Room	15	—
		Prepack	25	1 (4)
		Total	40	1 (3)
	Others	Cleaning	6	—
		Despatch	7	—
		Driving	9	2 (22)
		Maintenance	6	—
		Clerical	15	—
		Total	43	2 (5)
	Totals		120	10 (8)

* Figures in parentheses are percentages.

packing work surface and taps in the men's lavatory. Two wounds yielded mixed staphylococci and streptococci, four yielded pure staphylococci and one yielded pure streptococci. Nasal carriage of *Staph. aureus* was with strains of different phage types from those in wounds but phage type 85 staphylococci were isolated from a worker's bitten fingernails without signs of infection.

Infected workers and carriers were treated appropriately and taps and handles were cleaned regularly with dilute hypochlorite solution. No further cases of infection were seen.

Outbreak at Firm B

At a pork-processing factory with 120 employees 1600 pigs are slaughtered per week in cramped conditions originally intended to manage only one third of this work. After slaughter the carcasses are processed in the factory in various ways including curing in strong brine, de-boning, the production of sausages and slicing and packing of bacon and gammon.

A general practitioner reported a worker with infected hands and this led us to visit the factory in early December 1980. The management showed us ten workers with infected cuts on the hands or arms. They considered this number of infected workers to be normal for the factory at any time. The infections appeared generally mild but in several cases the wounds had not healed 6 weeks after injury and some showed considerable gaping. Details of the staff affected, the causes of injury and

Table 2. *Initial causes of infected lesions and bacteriological findings in autumn outbreaks at Firms A and B*

Category	No. of staff infected	Cause of infected lesion				Bacteriological findings				
		Bone	Knife	Other	Not known	No. of staff tested	*Strep. pyogenes* in Wound	*Strep. pyogenes* in Nose/throat	*Staph. aureus* in Wound	*Staph. aureus* in Nose/throat
				Firm A						
Butchers	8	6	2	—	—	10	2	2	6	6
Packers	3	—	—	1	2	7	1	1	—	2
Others	0	—	—	—	—	1	—	—	—	1
Total	11	6	2	1	2	18	3	3	6	9
				Firm B						
Butchers	7	2	2	3	—	7	3	—	7	—
Packers	1	—	—	—	1	1	—	—	1	—
Others	2	2	—	—	—	2	2	1	2	1
Total	10	4	2	3	1	10	5	1	10	1

bacteriological findings are shown in Tables 1 and 2. Sharp bones were the commonest single cause of injury. *Staph. aureus* resistant to penicillin and almost exclusively of phage type 53/85 was cultured from all the wounds and from taps in the sausage room. There were no nasal carriers and only one throat carrier of this strain. Two wounded patients who worked with strong brine had long-standing and extensive staphylococcal folliculitis on the dorsum of the hands. Tetracycline-sensitive *Strep. pyogenes* T-type 3/13/B3264, M negative, OF negative was isolated from five workers with wounds, one of whom was also a throat carrier. The average length of employment of those with streptococcal infection was 25 months compared with a general factory average of 28 months.

Tetracycline-susceptible β-haemolytic streptococci of Lancefield group L were cultured in heavy growth from a wound on the hand of a worker in the boning room who had trapped a finger between trolleys and similar organisms were grown from pig blood stains, the handle of the killing machine and taps in the scalding and boning rooms. Beta-haemolytic streptococci negative in tests for groups A, B, C, D, E, F, G, H, L, P, R and S were isolated from a worker's bitten fingernails without signs of infection and from taps in two rooms in the factory. Group C streptococci were isolated from handles of boning knives.

The infected workers received treatment with appropriate antibiotics.

Hand inspections in a non-epidemic period

We visited both firms in January 1981, when there was no outbreak of infection, to assess the prevalence, causes and sepsis rate of cuts on the hands and wrists of workers. Abnormalities of the nails were noted and we questioned workers about the wearing of gloves. The data from these investigations are shown in Table 3.

We interviewed 16 of 18 workers employed at Firm A at the time and a sample of 50 workers in the meat handling jobs at Firm B. The sample was limited by the time available and we believe there was no particular bias in the selection of workers. Thin plastic gloves were sometimes worn, particularly by packers, and men working in cold stores sometimes wore woollen gloves. Abnormalities of the fingernails were found in 50% of workers and included nail-biting, tears in nails softened by the wet conditions and a case of psoriatic nail dystrophy. Nail-biting, often severe, was seen in one third of the workers. Cuts were present on the hand or wrist of 39 of 66 workers (59%) but in only five of these (13%), all butchers, was there evidence of sepsis. The age of the cuts varied from 1 day to 1 month but nearly all had occurred within a week of the examination. Swabs from the infected cuts yielded penicillin-resistant *Staph. aureus* in all but one and *Strep. pyogenes* was not isolated. One of the infected workers at the pork factory also had acute paronychia on one finger without nail-biting and group L streptococci were isolated in scanty growth from the nail fold. Of the causes of cuts sharp bone was commonest (31%), followed by knife (21%) and various other causes at work (13%) including meat hooks, tongs, packing boxes, wires and thorns caught in the fleece of sheep. Lesions acquired outside work were also common (31%) but were often relatively trivial and caused in the exercise of hobbies, sports and duties with the fire brigade or by pet animals. Of all the workers only two, newly-employed, denied ever having been wounded at work.

The distribution of isolates of *Strep. pyogenes* and *Staph. aureus* from wounds

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Table 3. *Prevalence and causes of injury to the hands of workers at Firms A and B in a non-epidemic period*

Category	No. of staff studied	Number wearing gloves			Fingernails				Number with current lesions						
		Nearly always	Some-times	Never	Bitten	Torn	Diseased	Total damaged	Total with lesions	Lesions from work caused by				Lesions from home	Clinically infected
										Bone	Knife	Other	Not known		
Firm A															
Butchers	10	—	—	10	3	2	—	5	8	2	3	2	—	1	2
Packers	4	—	4	—	2	—	—	2	3	1	—	—	—	2	—
Others	2	—	—	2	1	—	—	1	—	—	—	—	—	—	—
Total	16	—	4	12	6	2	—	8	11	3	3	2	—	3	2
Firm B															
Butchers	22	2	4	16	8	4	1	13	17	8	4	1	2	2	3
Packers	23	3	12	8	7	2	—	9	8	—	—	2	—	6	—
Others	5	2	1	2	1	2	—	3	3	1	1	—	—	1	—
Total	50	7	17	26	16	8	1	25	28	9	5	3	2	9	3

Table 4. *Distribution of* 28 *isolates of* Streptococcus pyogenes *and* Staphylococcus aureus *according to the cause of wound* (21 *wounds*: 17 *in outbreaks*, 4 *in non-epidemic sepsis*)

Cause of lesion	No. of isolates from infected lesions		
	Strep. pyogenes	*Staph. aureus*	Total
Bone	6	12	18
Knife	1	3	4
Other	—	2	2
Unknown	1	3	4
Total	8	20	28

in the outbreaks and the non-epidemic study according to the cause of wound is shown in Table 4. Of the total isolates from wounds of known cause 75% were from lesions caused by bone.

Observations of cut bone and its fragments

In these firms the bones of the carcasses are cut early in the process after slaughter using high-speed rotary saws. Most carcasses are divided longitudinally through the vertebral column, sternum and pelvic girdle and decapitation and dismemberment of limbs is performed through the joints. Cut bone is often knife-sharp where the saw passes tangentially through the cortex and the medullary surface is abrasive and can bear sharp projecting spicules. Sharp pieces, often hard to see, can become detached from the bones and remain fixed to the meat. Bone dust is produced by the saws and blown widely over the surface of the carcasses, adjacent environmental surfaces and equipment. The dust consists of pale spicules and flakes usually less than a millimetre in diameter and, mixed with fat and tissue debris, it becomes adherent to surfaces. The dust appears similar whether from sheep, cattle or pigs and we found that it can be implanted in the edges of 'wounds' if sharp bones are pushed experimentally into 2% agar in Petri dishes. We made no bacteriological study of the bones or dust.

DISCUSSION

These outbreaks of streptococcal infection have several features in common with others reported in meat handlers (Fraser *et al.* 1977, 1979), including occurrence in the autumn, principal involvement of staff directly handling meat, infection with characteristic 'meat-associated' types of streptococci and concurrent infection with *Staph. aureus*.

There were differences in the character of the two outbreaks. At Firm A 52% of the employees were affected and some workers experienced serious infection. In the outbreak at Firm B we examined 8% of the work force and it is unlikely that many more than this were affected; all the cases we saw appeared clinically mild. The management at Firm A were aware of an outbreak whereas at Firm B they considered the amount of sepsis to be no greater than usual. Overcrowding in the pork factory might have contributed to the spread of infection. There seems to

be a tradition amongst butchers that newly-employed meat handlers are particularly liable to infection. In the outbreak at Firm A streptococcal infection was seen mainly in workers newly-employed at the opening of extensions to the abattoir in September. At Firm B there was no predominance of streptococcal infection in the newly-employed. Tsai *et al.* (1979) reported an outbreak of streptococcal infection that started within 3 weeks of the opening of an abattoir. The butchers' belief implies that older workers develop a degree of clinical immunity. Studies have shown that the development of type-specific antibodies is generally poor in streptococcal skin sepsis (Widdowson *et al.* 1974; Bisno & Nelson, 1974) but this has not been studied in meat handlers.

Staph. aureus is quite commonly isolated from lesions of streptococcal impetigo and there is evidence to suggest that it contributes little to the infection (Dillon, 1972) but the significance of this organism in the deeper lesions of meat handlers is unknown. It is recognized that *Staph. aureus* can multiply in wounds without producing disease and Williams & Miles (1949) described such latent infection in an extensive study of industrial wounds of the hand. The majority of strains of *Staph. aureus* in our outbreaks were lysed by phase 85 and, with variable strength of reaction, by phage 53. We found only one respiratory tract carrier of this type in the outbreaks. Infection with *Staph. aureus* of phage type 53/85 in another outbreak of streptococcal sepsis in meat handlers has recently been described (Morris, 1980).

The emphasis in our limited bacteriological studies of the environment was on sites of shared contact by workers, such as taps, knife handles and working surfaces. We recovered *Strep. pyogenes* and *Staph. aureus* from taps in the lavatories. Group L streptococci were cultured from various environmental sites at Firm B; in the boning room they were isolated from the taps and from two workers with infection but it is not clear whether they were the cause of infection. There are few reports of group L streptococci causing human infection but Duma *et al.* (1969) described the isolation of these organisms from an abscess on the hand of a butcher who handled pork. Group L streptococci are found in the normal vaginal flora of the pig (Wilson & Miles, 1975) and they can also cause pneumonia and endocarditis in this animal (Ross, 1972). The group L streptococci we isolated were almost certainly coming from the pigs.

Packers were the only group of staff to wear gloves with any regularity and the commonest type was one of thin plastic. These give little protection against accidental injury but might help prevent secondary microbial contamination of wounds. We encountered no sharing of gloves. Fifty percent of workers had damaged fingernails including a surprisingly high proportion of nail-biters (33% of the workers). In many cases the peri-ungual skin was also grossly bitten. Nail-biting can lead to acute paronychia (Samman, 1972). We swabbed the bitten fingernails of four workers in the outbreaks and isolated the epidemic strain of *Staph. aureus* from one. Of the four throat carriers of *Strep. pyogenes* or epidemic *Staph. aureus* in the outbreaks we could examine only three, and they were all nail-biters. It is possible that the organisms were introduced into the mouths of these workers by nail-biting and that contamination of the environment by respiratory tract carriers might also be related to the habit. Colonization of the respiratory tract has been found in about one third of patients with streptococcal

skin infection and is considered to be a secondary event (Dillon, 1972). Positive cultures from the fingers are to be found in many patients with upper respiratory tract infection or carriage with *Strep. pyogenes* and *Staph. aureus* (Boisvert & Powers, 1944; Hamburger & Green, 1946; Williams *et al.* 1966). The part played by nail-biting in the spread of organisms to and from the upper respiratory tract and the extent of carriage of organisms on the damaged skin of bitten fingers appear not to have been assessed.

A high proportion of workers examined had current wounds on the hand (59%) and 13% of wounds showed evidence of sepsis at a non-epidemic time. *Staph. aureus* was isolated from most of these wounds but *Strep. pyogenes* was not recovered. These results are similar to the findings of the Working Group on Streptococcal Infection in Meat Handlers (1979) who reported lesions in 37% of meat handlers, a wound sepsis rate of 11% and the isolation of *Strep. pyogenes* from 3·1% of wounds. In control groups of workers the Working Group found injuries in 35% in light engineering, 21% in cheese-making, 19% in fish handling and 13% in poultry processing but *Strep. pyogenes* was isolated from none of these workers. Outbreaks of streptococcal skin infection in poultry processors have been described recently (Barnham, Kerby & Skillin, 1980*a*, 1980*b*). Williams & Miles (1949) encountered a low level of *Strep. pyogenes* infection in the wounds of light engineering workers and this was further reduced by improvements in wound dressing techniques. Fleming & Porteous (1919) reported a very high incidence of *Strep. pyogenes* in infected war wounds and gave evidence to suggest that this was mostly caused by cross-infection during the dressing of wounds. There was no sick room in the two firms examined and most wounds went undressed. However, at Firm A there was encouragement from the management to cover the larger wounds with occlusive plasters and such dressing and redressing was done in the administrative office. We have no evidence to implicate this practice in the spread of infection.

Bone can produce a variety of injuries varying from grazes and simple punctures to large lacerations. These injuries are usually more traumatic than the single slicing injuries caused by knives and butchers complain that they are more painful and often become inflamed. Bone was the leading single cause of injury at work, being responsible for 31% of all wounds at a non-epidemic time and 48% of the wounds which became infected in the outbreaks. Butchers had the highest overall rates of wounding and the highest attack rates in the outbreaks of infection; most bone-inflicted injury was seen in this group. Bone was the cause of ten out of 25 butchers' wounds (40%) in the non-epidemic study and eight out of 15 infected butchers' wounds (53%) in the outbreaks. Table 4 shows that of the total isolates of *Strep. pyogenes* and *Staph. aureus* from wounds of known cause 18 out of 24 (75%) were from lesions caused by bone. It is clear from these findings that bone is an important cause of injury in meat handlers and that infection can develop in the wounds. We are not able to assess any special relationship there might be between bone and infection because the scale of our enquiry was small.

We have shown that bone dust and fragments are easily implanted from sharp bones in experimental agar 'wounds' and that the carcasses and certain areas of the environment are heavily contaminated with such fragments, which could enter existing wounds on the hands of workers. In the cold conditions which prevail in

abattoirs in the autumn and winter wounding often goes unnoticed by the workers, and few wear gloves to prevent subsequent contamination of wounds. If bone contamination occurs in the wounds there might be consequences for the initiation of infection by organisms inoculated with or independently of the bone. In experimental staphylococcal infection in mice small inocula can initiate infection in the presence of foreign bodies (Noble, 1965). In the Syrian hamster model of streptococcal impetigo the presence of particles of talcum powder, starch or filter cel potentiated infection with *Strep. pyogenes*, increasing the severity of lesions and greatly reducing the minimal infective dose of streptococci (Dajani & Wannamaker, 1970). It is a principle in the surgical management of wounds that foreign bodies should be removed. Bone fragments cannot be regarded as simple, inert foreign bodies. Untreated heterologous bone is antigenic, particularly by nature of its serum and cellular constituents, and is usually rejected by the recipient; hypersensitivity states are common in experimental guinea pigs repeatedly challenged with foreign bone (Burwell, 1964; Council on Drugs, 1966). Heterologous bone of bovine and porcine origin has been used in orthopaedic surgery after treatment to remove protein and cellular elements and it is then well-tolerated (Hallen, 1966). It is unclear whether the inflammation familiar to butchers in lesions caused by bone is due mainly to trauma, allergy or infection.

Erysipeloid and cutaneous anthrax in meat handlers may be acquired in various ways including bone-inflicted injury (Hunter, 1978; Barber, 1948; Klauder, Kramer & Nicholas, 1943; Brachman, 1977). In a large outbreak of erysipeloid in a factory producing buttons from bone there was a very high attack rate amongst injured workers sawing and cutting bones; conjunctivitis and respiratory infection associated with bone dust was also seen (McGinnes & Spindle, 1934). Erysipeloid and cutaneous anthrax associated with the handling of bone-meal has been related to contamination of pre-existing injuries in most of the published cases (Lawson & Stinnett, 1933; Jamieson & Green, 1955; Green & Jamieson, 1958). It is not possible to assess from these reports the influence of wound contamination with bone fragments: the accounts might simply reflect the predominance of bone as a cause of injury and as a source of infecting organisms.

Streptococcal infection seems to occur predominantly in those groups of meat handlers most exposed to sharp bone and its fragments. We have shown that bone is the principal cause of injury in two meat handling firms but it remains unknown whether there is any special relationship between bone-inflicted injury and infection. If potentiation of infection in wounds contaminated by bone does occur it could be a significant factor in the initiation of infection and the development of outbreaks.

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