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Blood in the respiratory tract during slaughter with and without stunning in cattle

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ABSTRACT

Bovine respiratory tracts were examined for blood following shechita without stunning, halal slaughter without stunning, and captive bolt stunning with sticking. In all three methods the cattle were in the upright (standing) position at the start of bleeding. Those that had not been stunned continued to breathe during the early part of bleeding whilst those that were stunned were not breathing. Nineteen percent of the shechita, 58% of the halal and 21% of the stunned plus stuck cattle had blood lining the inner aspect of the trachea. Thirty six percent, 69% and 31% had blood in the upper bronchi, respectively. Ten percent, 19% and 0% had fine bright red blood-tinged foam in the trachea, respectively. It was concluded that concerns about suffering from airway irritation by blood could apply in animals that are either not stunned before slaughter or do not lose consciousness rapidly whilst blood is present in the respiratory tract.

1. Introduction

Some authorities claim that aspiration of blood into the upper respiratory tract and lungs causes suffering during slaughter without stunning (von Wenzlawowicz & von Holleben, 2007; Webster, 1994). Others take the view that there will be no suffering because afferent signals activated by lung irritants are conveyed by neurons in the vagus nerves (King, 1999), and these are severed during slaughter without stunning.

More recently, it has been shown in laboratory animal species that there is a collateral spinal afferent pathway between the lower respiratory tract and the brain, which passes through the cervicothoracic (stellate) ganglia and the dorsal root ganglia at T_{2-4} (Qin, Foreman, & Farber, 2007a). This nervous pathway can relay signals that are interpreted in humans as tickling, tearing, aching or burning sensations provoked by chemical and physical stimuli in the lower respiratory tract (Hummel, Sengupta, Meller, & Gerhart, 1997; Morton, Klassen, & Curtis, 1950). If the same spinal pathway exists in ruminant species and if blood enters the respiratory tract during slaughter, then blood in the respiratory tract could be a welfare concern during slaughter without stunning, especially in those animals that do not lose consciousness promptly.

The aim in this study was to determine the prevalence of blood in the respiratory tract of cattle during slaughter without stunning. Following shechita the lungs are normally inflated during the bedika procedure, to allow examination of the pleura for imperfections. This study included examination for blood in lungs that had been inflated as well as not inflated, and it compared the findings with cattle slaughtered without stunning by halal or stunned by captive bolt and then bled.

2. Materials and methods

Animals with lungs that were affected by pneumonia or abscesses or were incised during evisceration were excluded from the study.

2.1. UK abattoir

A total of 229 cattle of mixed breed (range in cold carcass weight 160–510 kg) were slaughtered at an abattoir in the UK. One hundred and twenty three animals were slaughtered by shechita in the upright position without stunning. The cut was made upwards and across the ventral aspect of the neck, whilst the animal was restrained with a neck yoke, chin lift and belly supporting plate. One hundred and three animals were restrained in the same way in the restraining pen used for shechita, and stunned in the frontal position with a captive bolt gun (Matador, Termet

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Solefi, Champagne France) before sticking by the gash method (Gregory, 1998).

Seventy nine of the 123 shechita-slaughtered cattle were subjected to lung inspection by the conventional bedika method. After removal of the lungs from the carcass, an inspector (bodek) clamped the severed end of the trachea to a nozzle that delivered compressed air to the lungs whilst operating a foot switch. The inflated lungs were examined by the bodek for adhesions and holes in the pleura.

Following the bedika procedure, and before the lungs were inspected by the Meat Hygiene Service inspector, the lungs were examined by the investigating scientist for the presence of blood lining the inner wall of the trachea and major bronchi. Each set of lungs was placed dorsal surface uppermost on a table, and a knife was used to open the trachea and bronchi. Bloody foam was noted when it was present. In addition, the amount of blood lining the inner surface of each trachea was subjectively scored in the following way: 0 no blood; 1 some blood present but less than 10% of the inner surface area of the trachea; 2 blood covered 11–50% of the surface area; 3 blood covered more than 50% of the surface area.

Forty four sets of lungs from the shechita-slaughtered cattle (36%) were not inflated post-mortem either because the bodek could not keep up with the slaughter-rate or because the carcasses were unsuitable for the kosher market. Sixty three sets of lungs from the stunned cattle (61%) were inflated using a simulated bedika procedure, and 40 (39%) were not inflated to establish comparability with the shechita group. The tracheas and bronchi from the stunned and bled cattle were examined for blood in the upper respiratory tract using the same scoring method.

An additional three cattle were stunned by captive bolt and stuck. Each trachea was infused with 40 ml heparinised blood after the lungs had been removed from the carcasses. The infused blood was allowed to drain to the lungs, and the lungs were rotated to encourage blood distribution to the alveoli. The lungs were then inflated and the trachea and bronchi scored for blood using the same method as for bedika.

2.2. Belgian abattoirs

A total of 124 cattle were slaughtered by the halal method at two abattoirs in Belgium (89 and 35 cattle at abattoir A and B, respectively). The cattle were predominantly Belgian blue, Belgian blue crosses or purebred Holsteins, with carcass weight varying between 252 and 690 kg. At both abattoirs they were restrained in the upright position in a pen with the head secured by a yoke and chin lift, but there was no belly supporting plate. The cut was made by halal slaughtermen from below the neck and upwards. At abattoir B the cattle were released from the head restraining system as soon as the cut had been made, and this allowed them to stand unrestrained whilst bleeding. The time to loss of stability of the animal before ejection from the slaughter pen was recorded at each abattoir. Loss of stability at abattoir A was identified from loss of erect standing posture and included subsidence of the hindquarters, loss of support by the forelegs and buckling at the knees or spreading of the forelegs. Time to collapse at abattoir B was identified from the time the animal was no longer standing on its four-feet and did not return to four-foot stance. The glottis was examined as soon as the body was ejected from the slaughter pen in 28 cattle (24 and 4 for abattoirs A and B, respectively). The tracheas and bronchi were examined for blood contamination in the same way as for shechita except that none of the lungs were inflated following evisceration. The relationship between the presence of a fine bright red blood-tinged foam in the trachea plus both bronchi and the time to onset of collapse of the animal was examined in 56 cattle at abattoir A and for 35 cattle at abattoir B.

The presence of lobular haemorrhages was scored in lungs removed from 35 halal slaughtered cattle at abattoir B. The outer aspect of the lungs was closely inspected for signs of haemorrhage. When a haemorrhage was detected, it was cut and the edges squeezed to express blood to confirm that the haemorrhage was fresh.

Statistical analysis was by Fisher's exact test.

3. Results

3.1. UK abattoir

There was no difference in the prevalence of blood (score 2 + 3) lining the trachea between lungs that were inflated or not inflated after removal from the carcass (20% of the animals in each case). Similarly, there was no difference in the proportion of inflated sets of lungs that had blood in the bronchi compared to non-inflated lungs (36 versus 30%, respectively). On account of this lack of difference, and for clarity of presentation, the results for the inflated and non-inflated lungs have been pooled for comparing shechita with captive bolt stunning plus sticking (Table 1).

Nineteen percent of 123 cattle slaughtered by shechita had substantial amounts of blood in the trachea (covering >10% of the inner surface area), and 36% had blood in the bronchi (Table 1). These frequencies were similar to those for the 103 cattle shot by captive bolt and stuck (secular slaughter) whilst in the same upright position (21 and 31%, respectively). Ten percent of the shechita cattle had a bright red blood-tinged foam in the trachea, whereas none of the secular cattle had a blood-tinged foam lining the trachea.

Nine tracheas were heavily contaminated with blood (score 3), 8 of which were from cattle slaughtered by shechita. In 6 of those 8 shechita cattle the blood lining the trachea was present as a fine bright red blood-tinged foam. In total there were 12 tracheas that had this fine red foam, and all were from shechita slaughtered cattle.

When heparinised blood was infused via the trachea, and the lungs inflated by a simulated bedika procedure, all tracheas had a blood contamination score of 3, but none had the fine red foam seen in the shechita slaughtered cattle.

None of the cattle stunned by captive bolt showed breathing movements after they were shot.

3.2. Belgian abattoirs

The frequency of tracheas containing blood following halal slaughter was 58%, and 19% had a fine bright red blood-tinged foam (Table 1). Twelve percent of the tracheas were heavily contaminated with blood (score 3), and in 53% of those cattle the blood lining the trachea was present as a fine bright red blood-tinged foam. The proportion of cattle with blood contamination on the caudal surface of the glottis was 100% (28 out of 28).

At abattoir A, loss of stability following the cut occurred whilst the cattle were held by the head and neck in the upright position. The time to onset of loss of stability was 33 ± 4 s ± se (range 8–180 s, $n = 63$) following the cut. Six animals got up again after the initial subsidence. Allowing for this behaviour, the time to final loss of stability following the cut in the 63 cattle was 37 ± 4 s ± se (range 8–180 s). The frequency distribution of time to first loss of stability was unimodal but with an extended upper time limit (Fig. 1). A higher proportion of the animals that had a fine blood-tinged foam in the trachea plus both bronchi lost stability within the first 30 s following halal slaughter, compared with those that had no fine blood-tinged foam in the lower respiratory tract (90 versus 48%, $p < 0.05$).

At abattoir B the cattle were immediately released from the head restraint after the halal cut, and two animals stood up after

Table 1
Frequency of blood contamination in the lower respiratory tract during three slaughter methods.

	Shechita	Halal	Secular slaughter
Number of cattle	123	124	103
Blood in trachea (% of animals)			
0 + 1	81^{a}	42^{b}	79^{a}
2 + 3	19^{b}	58^{a}	21^{b}
Bright red foam	10^{b}	19^{a}	0^{c}
Blood in bronchi (% of animals)	36^{b}	69^{a}	31^{b}

Means in a row without a common superscript letter were significantly different at least at $p < 0.05$.

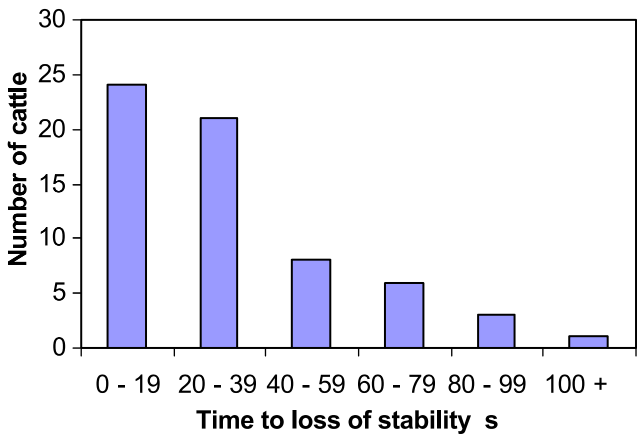

Fig. 1. Frequency distribution of time to loss of stability (s) during halal slaughter in cattle.

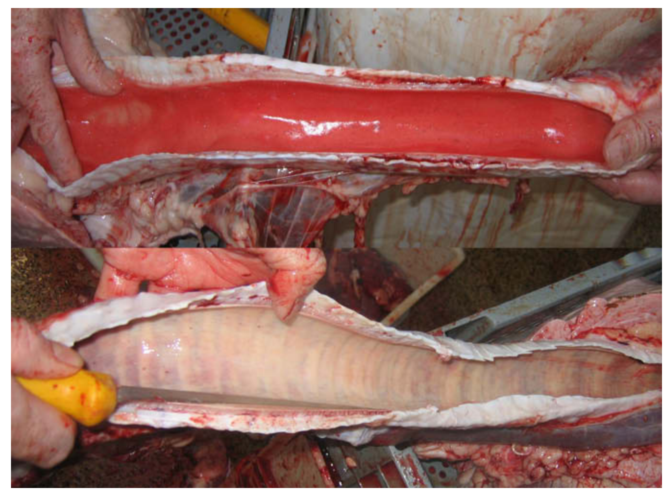

Fig. 2. Cattle tracheas examined after halal slaughter, showing no blood (lower photograph) and a fine blood-tinged foam (upper photograph).

the initial collapse. The average time to final collapse was 16 ± 2 s ± se, but it varied substantially between animals (range 6–65 s). In this group of animals there was no clear relationship between the time to final collapse and the presence or absence of blood-tinged foam in the trachea plus both bronchi.

Lobular lung haemorrhage was present in 63% of the 35 animals, and 47% of the lungs, that were inspected for this feature. In 73% of the affected animals, the overall outer surface area of the haemorrhagic region was small (less than 50 cm^2).

An example of the fine bright red blood-tinged foam which completely covered the inner surface of the trachea is shown in Fig. 2.

4. Discussion

This study showed that blood entered the trachea in animals that were bled whilst restrained in the upright position. Blood entered the respiratory tract in animals that were shot with a captive bolt and stopped breathing, as well as those that were slaughtered without stunning and continued to breathe after the start of bleeding. It was concluded that blood entered the trachea and bronchi irrespective of whether or not the animals were breathing. In other situations, decapitation has also been found to be associated with blood in the respiratory tract, and this was presumed to be due to aspiration (Tsokos, Türk, Uchigasaki, & Püschel, 2004).

Fluid in the respiratory tract in conscious animals leads to irritation of sensory receptors lining the airway, and in particular the receptors on the glottis and the carina of the trachea. In animals that have intact vagus nerves, lower respiratory tract irritation provokes a cough or expulsion reflex, but coughing would be absent when the vagi have been severed (Canning, 2007). In a study of 347 cattle undergoing shechita and halal slaughter without stunning (Gregory et al., 2008), over 90% had both vagi completely severed. So, a cough reflex would not be expected in the majority of animals in this situation even though lower airway irritation may occur through sympathetic-spinal afferent pathways (Qin et al., 2007a). Severing the vagi can modulate sensory and nociceptive signals conveyed by the spinal afferent pathway (Qin, Foreman, & Farber, 2007b). The modulation can be either excitatory or inhibitory depending on the individual spinal neurons and their site of origin within the lung.

Blood impacting the glottis could cause upper respiratory tract irritation. Under normal circumstances, upper respiratory tract irritation activates the cranial (superior) laryngeal nerve which merges with the Xth cranial nerve before entering the brain. Contamination of the caudal aspect of the glottis with blood was examined in 28 halal slaughtered cattle, and in all animals blood coated that surface during the early stages of bleeding. During shechita and halal, the neck is usually cut at C3 or C4. According to the hagrama Halachic requirement in shechita, the cut must be below the cricoid, and when shechita is performed by kedassia and some other sub-divisions of the jewish faith the cut may be made at C4 to C5 to ensure a reasonable length of oesophagus is left at the cranial end of the cut. If the cut was made at C2, there would be a greater chance of cutting the afferent projections of the cranial laryngeal nerve that convey signals associated with laryngeal irritation (Godinho & Getty, 1975). The present study indicated that the likelihood of activation of laryngeal receptors is high, as all the animals that were examined had blood lining the luminal aspect of the larynx.

The efferent pathway executing the cough reflex in response to upper respiratory tract irritation is partly through the recurrent laryngeal nerve. This nerve would normally be severed along with the vagus nerves during shechita and halal slaughter, and so a coordinated coughing action would not be expected. Coughing occurs whilst forcing gases in the respiratory tract against a closed glottis. It involves a pressurised respiratory system which would not normally exist during shechita and halal slaughter because of the severed trachea. A synchronised cough response could not occur, and in this situation absence of obvious coughing would not be a sign of absence of respiratory tract irritation.

A fine blood-tinged foam in the respiratory tract indicates that blood has been expelled from the lungs following churning in the alveoli through breathing actions. The blood contributing redness to the foam could enter the alveoli either from the pulmonary capillary bed if there is rupture of the alveolar-capillary barrier, or by aspiration with air taken in through the severed trachea. It was not clear whether rupture of the alveolar-capillary network during bedika or agonal respiration contributed substantially to the presence of a fine bloody foam in this study, but five points are worth noting. Firstly, when bedika was simulated in secular slaughtered cattle, there was no fine blood-tinged foam in the lower respiratory tract. Secondly, when unclotted blood was introduced into the trachea of secular slaughtered cattle and the lungs inflated using a simulated bedika procedure, there was no fine blood-tinged foam in the trachea but there were large dark red bubbles in the bronchi. Thirdly, it might be claimed that the fine blood-tinged foam was not derived from a ruptured alveolar-capillary network because the lungs would be progressing to the exsanguinated state by the time respiratory agonal spasms set in. In other situations, raised capillary blood pressure in combination with negative airway pressures can lead to rupture of the alveolar-capillary barrier and the formation of blood-tinged foam in the lower respiratory tract (Slade, Hattori, Ray, Bove, & Cianci, 2001). During slaughter without stunning, presumably much of the caudal venous return has to pass through the lungs before it escapes through the severed carotids, in which case the lungs may not drain rapidly and this may increase the opportunity for blood-tinged foam formation from a ruptured alveolar-capillary network. Fourthly, whilst the negative airway pressures generated during agonal inspiratory heaves could in other situations cause breakdown of the alveolar-capillary barrier, this would be less likely during slaughter without stunning because the trachea has been severed and glottis closure would be ineffective. Occlusion of the severed end of the retracted trachea by surrounding tissues may, however, allow negative airway pressures to occur in some animals. Lastly, a substantial proportion (63%) of halal slaughtered cattle had lobular haemorrhages in the lungs, and so rupture of the alveolar-capillary interconnections can still occur, and presumably these could have contributed to the blood-tinged foam in the airway.

At one of the halal abattoirs, cattle that developed a fine blood-tinged foam in the lower respiratory tract usually lost stability of the body within 30 s of the cut, whereas many of those with no foam lost stability later than this. One interpretation for this is that an early rapid release of blood could favour blood aspiration and an early loss of physical stability. The higher prevalence of blood aspiration in the halal slaughtered cattle compared with shechita may be circumstantial rather than a difference in religious slaughter method. Similarly, it is not entirely clear why there was such a large difference in time to loss of control over posture between the two halal abattoirs, but it may relate to the additional restraint used at abattoir A.

It is concluded that the concerns about blood aspiration in the lower respiratory tract and about blood contamination of the surface of the glottis in the upper respiratory tract are warranted for a proportion of cattle slaughtered without stunning. Hitherto, concerns about blood aspiration have mainly focused on cattle held in the inverted position when the cut is made (Blokhuis et al., 2004), but this study indicates that the concerns can also be warranted for cattle slaughtered in the upright position. Blood may enter the lower respiratory tract either through the severed trachea or from a haemorrhage in the lungs. An effective expulsion or cough response to irritation of the respiratory tract would not be expected. It would be helpful in future work to determine the interval between the neck cut and contamination of the larynx and trachea with blood, to establish the risk of perception of airway irritation before loss of sensibility.

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