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# Arrested blood flow during false aneurysm formation in the carotid arteries of cattle slaughtered with and without stunning

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ABSTRACT

The time to onset of arrested blood flow and the size of false aneurysms in the severed carotid arteries were assessed in 126 cattle during halal slaughter without stunning. Thirty six cattle (29%) showed early arrest of blood flow. In 6%, both the left and right carotid arteries in the same animal stopped bleeding before 60 s had elapsed following the neck cut. The time to early arrested blood flow was on average 21 s, and this was accompanied by enlargement with false aneurysms which occluded the arteries. In the arteries which were still bleeding at 60 s after the neck was cut the artery size was normal. Based on comparative data from different slaughter premises it appeared that making the cut in the neck at the first cervical vertebra instead of the second to fourth cervical vertebrae reduced the frequency of false aneurysm formation and early arrested blood flow. This was confirmed in a separate controlled trial where 100 cattle were stunned with a captive bolt and the arteries were examined following neck cutting at either the C1 or C3 positions.



## 1. Introduction

When cattle are slaughtered by the halal or shechita methods their carotid arteries are prone to developing false aneurysms at the severed cardiac ends (Gregory et al., 2008). This can lead to delayed onset of unconsciousness and during the intervening period nociceptive neuronal signals can reach the brain (Gibson et al., 2009; Gregory, Fielding, von Wenzlawowicz, & von Holleben, 2010). False aneurysms are thought to develop when a severed artery end retracts within its surrounding connective tissue sheath (Gregory, Shaw, Whitford, & Patterson-Kane, 2006). Blood flowing from the severed end impregnates the adventitia and the artery end can become sealed as the adventitia swells with blood (Gregory, 2009). If bleeding is arrested in this way, blood can continue to flow to the brain via the collateral vertebro-basilar plexus which is particularly well developed in cattle (Anil, McKinstry, Gregory, Wotton, & Symonds, 1995; Baldwin, 1960). However, this will depend on how soon after the cut the severed ends of the carotid arteries become occluded.

The aims of this investigation were to determine how soon after neck cutting blood flow from the carotids can become arrested, and whether such cases are associated with false aneurysm formation in the arteries. In addition it examined the proportion of cattle slaughtered without stunning which showed premature arrest of blood flow from the severed carotid arteries. This work was conducted at slaughter premises in Indonesia, China and France. Indonesia is a predominantly Muslim country where cattle are normally slaughtered by the halal method without stunning. In China, cattle are usually slaughtered by the halal method without preslaughter or post slaughter stunning, even though Muslims are a minority group in that country. In France there is a growing Muslim community, and the meat industry is responding to the additional demand for halal slaughter.

## 2. Materials and methods

### 2.1. Indonesia

Halal slaughter was examined in 29 Brahman crossbred cattle of mixed age at six abattoirs in Java and four in Sumatra. At nine abattoirs the cattle were held in a galvanized steel restraining pen (MLA-Livecorp Mark 1) for attaching casting ropes to the legs. At the tenth abattoir the cattle were restrained in a traditional wooden pole race. In both systems, on release from the pen or race the cattle were cast and restrained on the ground with ropes. The head was secured either with a rope or by hand, and the neck cut by either a halal slaughterman or a mullah while the animal was in lateral recumbency

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with the neck twisted such that the ventral aspect was facing upwards. Liveweight and carcass weight were not normally measured at these premises, but it was estimated that liveweight varied between 400 and 800 kg.

### 2.2. China

Halal slaughter was assessed in 57 young *Bos taurus* bulls at two abattoirs in the East of China. The range in liveweight was 380 to 540 kg. At the first abattoir, 27 cattle were observed, and an operator stretched the skin on the neck by raising the chin to produce dorsoflexion of the neck while the animal was suspended from an overhead rail with a shackle attached to the left hind leg. The slaughterman then cut the ventral aspect of the neck. At the second abattoir 30 cattle were restrained individually in a 180° rotating pen fitted with a chin lifter which tensioned the skin overlying the ventral aspect of the neck. The neck was cut by a slaughterman from the animal's right hand side, while it was in the inverted position.

### 2.3. France

Halal slaughter was examined in 42 cull Holstein Friesian dairy cows, with an estimated liveweight of over 500 kg, while restrained in the 180° inverted position in a rotary pen fitted with a chin lifter. The cows were cut by an experienced and proficient halal slaughterman from the animal's right side. Immediately after the cut, the restraint provided by the mechanical chin lifter was reduced but the head was not released. This allowed the head to move laterally during the bleeding period.

### 2.4. United Kingdom

During the course of the work in China and France it appeared that the position of the cut across the neck could be influencing the risk of false aneurysm formation and early arrested blood flow. Unsuccessful attempts were made at arranging a controlled trial in which a halal slaughterman cut the neck at positions corresponding to C1 and, in separate cattle at the same premises, at C3. Instead, a trial was performed at a UK abattoir which normally shot the cattle with a captive bolt and then performed a neck cut once the animals had been suspended by a hindleg. The non-halal slaughterman performed the cut at the position corresponding to C1 in 50 captive bolt shot cattle by following the line of the lower jaw when making the first incision, and then continuing the cut through to the opposite side of the neck. The entry point for the cutting position corresponding to C3 was made in a more caudal point in the neck in 50 separate captive bolt shot cattle. Where there was doubt that the position of the cut may have deviated from the intended position, the location of the severed ends of the arteries relative to the cervical vertebrae was checked while the carcass was bleeding. Mean hot carcass weight for the cattle was 353 kg ± 40 sd. This trial was conducted at the same UK cattle abattoir and by the same slaughterman as that reported in Gregory et al. (2006).

### 2.5. General methods

In trials 2.1, 2.2 and 2.3 the cattle were slaughtered without pre- or post-cut stunning and they were held in the restrained position for at least 60 s after the cut. At those slaughter premises the number of cuts to the neck was recorded, where one cut represented a movement in one direction while cutting tissues in the neck.

Blood flow from both severed carotid arteries was monitored by palpation with the fingers placed in the path of the blood, and/or by visual inspection. The time from the onset of flow to cessation of flow was measured when flow ceased within 60 s of the cut(s) in trials 2.1, 2.2 and 2.3. In trial 2.4 the flow of blood was determined for the first 45 s following the cut and early arrested flow was recorded without noting the time of onset of the arrest. Normally, 40 to 50% of the blood is lost within 60 s, and blood loss can continue for up to 300 s following sticking (Gregory, Wilkins, & Gregory, 1986). As soon as blood flow stopped, the size of the cardiac severed end was assessed by palpation using the method of Gregory et al. (2006), where increasing score corresponded to increasing outer diameter of the artery. Previous experience showed that palpation was a reliable way of assessing the outer diameter of arteries with false aneurysms. The correlation coefficient between estimation of outer diameter by palpation ($y$) and measurement by ruler ($x$) was 0.96 (linear regression coefficient = 0.93; Gregory et al., 2006). Artery outer diameter was also assessed in all arteries at either 60 (trials 2.1, 2.2 and 2.3) or 45 (trial 2.4) s after the cut. Where the term 'arrested flow' is used in this paper, it means cessation of flow.

Statistical analysis was by Fisher's exact test. Confidence intervals were estimated using Wald's method.

## 3. Results

### 3.1. Indonesia

Three halal methods were used. In both Java and Sumatra, the most common method was to make the opening cut in the skin of the neck with reciprocating cuts which extended to the underlying soft tissues including the carotid arteries. In Java, an alternative method was to use the tip of the knife to pierce the skin in the side of the neck and then draw the blade as a single sweep through the skin and soft tissues which included the carotid arteries. The third method, which was only seen in Sumatra, used the knife as a cleaver to make an opening cut in the skin with a single chopping action. This was followed by reciprocating lateral cuts to sever the soft tissues including the carotid arteries.

The number of cuts varied considerably between slaughter premises. Twelve animals received only one cut, and on average there were 4.5 cuts (±4.5 sd), but in one animal there were 18. In all animals both carotid arteries were completely severed. At one slaughter premises the cuts were made in the ventral aspect of the neck at a position corresponding to C1. All the cattle at the other premises were cut in the neck at the level of C2 to C4. Combining the data for all abattoirs, in 29% of the arteries (in 48% of the cattle) there was arrest of blood flow from the severed ends of the carotid arteries within 60 s of cutting the neck.

### 3.2. China

In the 57 cattle the cuts were made as reciprocating cuts across the ventral aspect of the neck to open the skin and sever the soft tissues including the carotid arteries. There were two halal slaughtermen and they were considered proficient at their job, but at the abattoir where the cattle were suspended before slaughter, two animals did not have both carotid arteries completely severed. Those two animals have been excluded from the data analysis. On average the number of cuts made in the neck was 3.8 (±1.3 sd) and varied between 2 and 9 cuts. All the cattle at the first abattoir were cut in the neck in the region of C2 to C4. At the second abattoir all the animals were cut at a position corresponding to C1 and close to or through the arytenoid cartilages. Combining the data for both abattoirs, there was arrest of blood flow from the severed ends of the carotid arteries within 60 s of the halal cuts in 23% of the arteries (in 36% of the cattle). At the first abattoir where cattle were suspended before slaughter, 48% of the arteries (in 76% of the cattle) showed arrest of blood flow from the severed ends of the carotid arteries within 60 s of the halal cuts. At the second abattoir the cattle were in the inverted position on their backs, and 2% of the arteries (in 3% of the cattle) showed early arrest of blood flow.