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POULTRY SLAUGHTERING PROCEDURES

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INTRODUCTION In Britain, when domestic fowl are slaughtered for meat consumption they must be "instantaneously rendered insensible to pain until death supervenes" (Slaughter of Poultry Act, 1967). The only exceptions to this ruling are religious slaughter, decapitation and neck dislocation in which no prior stunning is required. In practice the birds are usually put through an electrical stunning bath to anaesthetise them, and then killed by cutting the blood vessels in the neck. Killing is achieved either manually by cutting the neck with a knife, or automatically with a machine which has one or two revolving blades. It has been reported that death can also be brought about satisfactorily by inducing a cardiac arrest at stunning (Heath, 1984), but this method is not widely used in British abattoirs or elsewhere. In this study it was decided to examine the possible humanitarian advantages of inducing a cardiac arrest at stunning in comparison with conventional neck cutting procedures. Comparisons were made in terms of the time to loss of evoked responsiveness and spontaneous activity in the brains of anaesthetised, mechanically-ventilated chickens and ducks. The experiments were performed on anaesthetised birds for ethical reasons, and they were ventilated so that the findings could be related to instances where birds are inadequately stunned. In this context it should be noted that when birds are inadequately stunned they will maintain or resume breathing after the stunning procedure and before death.

MATERIALS AND METHODS Appraisal of abattoir practice Eight manual and mechanical methods of bleeding were examined in commercial processing plants in the UK to establish which blood vessels are usually severed by each method. The methods included manual cutting at one side of the neck, manual Halal and Shechita neck cutting, manual cut per os ("beak cut" in ducks), 4 automatic killers including single-bladed machines made by Cope & Cope, Meyn Machinefabriek and Stork, and the dual-bladed machine manufactured by Lindholst. The necks of 22 (± 7SD) birds killed at each processing plant were dissected to establish which blood vessels had been cut.

Chicken experiments Seventy two cull laying hens (2.1kg ± 0.2 SD) were sedated with 98 mg kg^{-1} (± 14 SD) intramuscular ketamine hydrochloride. Anaesthesia was induced and maintained for the duration of the experiment with 47 mg kg^{-1} sodium thiopentone which was introduced through a wing vein. The birds were ventilated with air via a tracheotomy using a Harvard Standard Ventilator. Bipolar 0.5mm diameter silver-silver chloride electrodes with insulated shafts were implanted onto the cortex of the brain with the negative-going electrode at the optic lobe and the positive electrode at the frontal lobe. The eyelids of the animal were sutured open to allow exposure to a flashing light delivered at 2 flashes per sec. The light stimulus and the recording procedures for the evoked responses were similar to those described by Gregory and Wotton (1983).

The birds were divided into 9 treatments with 8 birds per treatment. Each bird acted as its own control and was subjected to the flashing light for a 265 sec period whilst ventilated with air. This control period was identical for each bird, but thereon the treatments varied as shown in Table 1. Ventilation was maintained following the onset of the experimental treatment for the first 6 treatments listed in the Table, and the ventilator was switched off at the onset of the remaining 3 treatments (e.g. at the time the incision was made). In the first 4 treatments discrete blood vessels in the neck were severed with a knife or scalpel blade. The spinal cord was severed using secateurs, and the cut included a vertebra, both vertebral arteries and the spinal cord arteries. Decapitation was performed at the third to fifth cervical vertebrae using a laboratory guillotine (5mm plate steel blades). Cardiac arrest was induced with a 35V, 50Hz current applied across the chest for 3 sec, and the effectiveness of the procedure was confirmed from a chest lead electrocardiogram. With this treatment only the results from those birds which developed a sustained ventricular fibrillation have been included in this report.

TABLE 1. Treatments used in the chickens

Treatment	Mode of operation of ventilator at onset of treatment
Bilteral carotid artery cut	On
Bilateral jugular vein cut	On
Unilateral jugular vein cut	On
Unilateral jugular + unilateral carotid cut	On
Cardiac arrest	On
Spinal cord cut	On
Spinal cord cut	Off
Decapitation	Off
Asphyxia	Off

In all the neck cutting treatments the site of incision was examined post-mortem to check that the required blood vessels had been severed. The flashing light was maintained during and following each slaughtering method, and the subsequent responses were averaged and quantified from their excursion distances (Gregory and Wotton, 1983). The spontaneous electrocorticogram (ECoG) was assessed from its integrated activity using a Texas E&M GPA-10 capacitance discharge integrator with its negative input referred to earth.

Duck experiments The procedures used in ducks were essentially the same as those for the chickens.

TABLE 2. Principal blood vessels severed at neck cutting

Neck cutting method		Species	Principal vessels severed
MANUAL	Transverse cut across one side of the neck	Chickens and ducks	Unilateral carotid artery + unilateral jugular vein
MANUAL	Lateral incision into the neck	Ducks	Bilateral carotid arteries + jugular vein anastomosis or unilateral jugular vein
MANUAL	Beak cut	Ducks	Jugular vein anastomosis
AUTOMATIC	Single blade	Chickens	Spinal cord + unilateral or bilateral vertebral arteries
AUTOMATIC	Double blade	Chickens	Bilateral jugular veins + unilateral vertebral artery
HALAL		Chickens	Bilateral carotid arteries + bilateral jugular veins + spinal cord + one or both vertebral arteries
SHECHITA		Chickens	Bilateral carotid arteries + unilateral jugular vein

Twenty four birds (3.5kg ± 0.5 SD) were divided evenly between three treatments as follows: cardiac arrest using a 30V, 50Hz current applied to the chest for 3 sec, bilateral carotid artery plus bilateral jugular vein cut, beak cut in which a blade was inserted within and along the length of the mouth to sever the vessels at the junction between the head and neck. The method used in placing the negative recording electrode differed from chickens, to allow for the deep location of the optic lobe in the duck's brain.

RESULTS Commercial neck cutting procedures

The usual procedure with manual bleeding was to make a single cut at one side of the neck. This normally severed one jugular vein plus one carotid artery, and a vertebral artery was sometimes included as well. Occasionally, an external carotid artery was also cut. The effect that different slaughtermen had was particularly noticeable at one duck processing plant, where one man often cut one jugular vein only whilst the other man cut a carotid artery as well. At another duck processing plant the manual procedure was performed by inserting a narrow bladed knife laterally through the side of the neck, and this usually severed both carotid arteries and either one of the jugular veins or the anastomosis between the two jugulars. Another method used in ducks was insertion of a knife into the bird's mouth to sever the blood vessels at the base of the skull. This usually cut the anastomosis between the two jugular veins.
The effect of the single bladed automatic killers depended on the make and setting of the machine and the size of the birds. With most machines the cut was made at the back and to one side of the neck, severing the spinal cord and the muscle enveloping one or more of the vertebral arteries. One make of machine, however, cut the ventral aspect of the neck, severing the oesophagus, trachea, both jugular veins, both carotids, and occasionally the spinal cord. The double bladed automatic killer was examined at one abattoir, and it cut both jugular veins plus one vertebral artery. In some birds the cut also included one of the external carotid arteries or one of the common carotid arteries.

In Halal slaughter, both jugular veins, both carotid arteries, the spinal cord, oesophagus and the trachea were cut. This procedure was similar to decapitation except that the head was left attached to the body by the muscle and skin at the back of the neck. Shechita involved a less extensive and more variable cut (Table 2).

Chicken experiments The object of the experiments was to determine which of the many slaughtering methods that are or can be used commercially cause brain failure in the quickest manner. Brain failure was assessed in two ways. Firstly, as loss in its response to an external stimulus, and secondly, as the decline in its spontaneous activity. The cortical responses were often biphasic, and after slaughter they gradually diminished to zero. The averaged responses for series of 32 consecutive stimuli were quantified by measuring their excursion distance for 140 msec following the flash of light. The time from slaughter to less than 50% and 5% of the preslaughter evoked excursion distance was then determined for each bird. These results are presented, along with the times to less than 50% and 5% of the integrated ECoG activity, in Table 3.

TABLE 3 Effect of 9 slaughtering methods on the time to less than 50% (t50) or 5% (t5) of the integrated spontaneous activity or excursion distance of the evoked response in the brains of chickens

Slaughtering method	Spontaneous activity (sec ± SE)		Evoked activity (sec ± SE)	
	t_{50}	t_5	t_{50}	t_5
Cardiac arrest	11 ± 1^{a}	23 ± 2^{a}	22 ± 4^{a}	90 ± 8^{a}
Decapitation	14 ± 1^{a}	32 ± 2^{b}	38 ± 5^{b}	136 ± 16^{b}
Bilateral carotid arteries	19 ± 4^{a}	60 ± 8^{c}	50 ± 9^{b}	163 ± 11^{bd}
Unilateral carotid artery + unilateral jugular vein	38 ± 6^{b}	122 ± 22^{cde}	116 ± 21^{c}	302 ± 30^{cf}
Spinal cord without respiration	53 ± 6^{b}	80 ± 8^{cd}	84 ± 7^{c}	190 ± 11^{d}
Asphyxia	56 ± 6^{b}	100 ± 13^{d}	98 ± 10^{c}	250 ± 17^{ec}
Spinal cord with respiration	106 ± 14^{c}	179 ± 29^{e}	206 ± 19^{d}	330 ± 11^{f}
Bilateral jugular veins	121 ± 19^{d}	185 ± 25^{e}	215 ± 21^{d}	332 ± 23^{f}
Unilateral jugular vein	180 ± 50^{cd}	233 ± 58^{e}	234 ± 14^{d}	349 ± 22^{f}

Means in each column with different superscript letters were significantly different at least at $p = 0.05$ using the Mann Whitney test.

Cardiac arrest and decapitation were the quickest slaughtering methods in terms of the time to loss (<5%) of spontaneous and evoked activity in the ECoG (Table 3). Cutting both carotid arteries took almost twice as long as a cardiac arrest in causing loss of the evoked response, and cutting the jugular veins only took the longest. When the spinal cord was cut, the time to loss of spontaneous activity was about 1.5 min longer when the ventilator was left on in comparison with switching it off. This suggests two things. Firstly, severing only part of the spinal cord, such that the animal is able to breathe spontaneously, may not cause death as promptly as severing the whole cord. Secondly, complete severance of the spinal cord (without cutting any of the 4 major blood vessels in the neck), causes death through asphyxiation. This conclusion was confirmed by the results for the asphyxia treatment. When the birds were not bled out at all, but the ventilator was switched off, the time to loss of spontaneous activity in the brain was similar to cutting the spinal cord plus switching off the ventilator.

Duck experiments Cardiac arrest was the quickest method of reducing evoked and spontaneous activity in the duck's brain, followed by the bilateral carotid artery plus bilateral jugular vein cutting method and then exsanguination through the bird's mouth (Table 4). In 7 birds subjected to the beak cut treatment the incision cut into a jugular vein or the anastomosis between the two jugulars. The remaining bird in this treatment had a superficial branch of the left carotid artery cut, whilst the jugular veins were left intact.

DISCUSSION The results from these experiments help to establish the rate at which various slaughtering methods induce a profound form of brain failure in chickens and ducks. Brain failure was assessed in two ways; from the loss of spontaneous activity in the ECoG and as failure in the brain to respond to an external (light) stimulus. The relevance of the results to commercial slaughtering practice depends on whether birds should be dead or merely unconscious at the time they enter the scalding tank. A minimum interval of 1.5 min is required between slaughter and scalding in British processing plants and it has been suggested that the slaughtering method should allow the birds to bleed to death before they are subjected to the scalding treatment (Farm Animal Welfare Council, 1982). If however it is simply sufficient for the animal to be irreversibly unconscious when it enters the scalding tank then the findings from this experiment are of less practical value. It is also important to note that in the majority of treatments used here, the birds were ventilated following the slaughtering procedure. This would simulate conditions where birds are inadequately stunned and hence able to maintain or resume respiration following neck cutting. Under normal circumstances, adequately stunned birds would not resume rhythmic breathing movements, although they might show some gagging.

The appraisal of processing plant practice showed that cutting into the spinal cord without severing the carotid arteries was the most common system used with single bladed automatic killers. The experimental work indicated that this method resulted in death through asphyxia, and, as such it would only be humane if the birds remained stunned up to the time they died. Since in slaughterhouse situations it is impossible to determine whether an animal is conscious or unconscious when it has had its spinal cord cut, it is suggested that this method should not be used in conjunction with electrical stunning methods which fail to induce a cardiac arrest. Severing the spinal cord is probably the preferred neck cutting method in commerce because it facilitates feather release at plucking (Levinger and Angel, 1977).

Cardiac arrest and decapitation were the quickest methods of killing chickens. Both methods however are associated with slow bleeding from the carcass (Weise et al, 1982; Davis and Coe, 1954), but it is not known whether this is important enough to affect the quality of the carcass. A cardiac arrest can be induced at stunning by using high voltages (Heath, 1984). Where this is not used it is important to sever both carotid arteries at slaughter to cause a rapid death. This would mean that either both sides of the neck have to be cut manually, or, the trachea has to be severed in order to reach the carotids when automatic killers are used. Cutting the trachea is said to be incompatible with present automatic evisceration methods, and so a unilateral cut is preferred in the processing industry where the manual method is used. This causes a delay in the onset to brain failure in comparison with cutting both carotids.

The reason for including ducks in this experiment was to compare the results for chickens with a diving bird species. Unanaesthetised ducks are known to sustain spontaneous brain activity for 5 times longer than chickens when subjected to apnoeic asphyxia (Bryan and Jones, 1980). This difference, however, was not present following cardiac arrest or any of the exsanguination methods used in this study. It appears that the species difference in response to asphyxia reported by other workers was probably mediated through an oxygen conserving cardiovascular reflex rather than an innate difference in brain tolerance to hypoxaemia.

It is concluded that from the humanitarian standpoint an electrical stunning method which simultaneously causes a cardiac arrest produces a quicker kill than conventional slaughtering methods, and so it is less likely to be associated with resumption of consciousness following stunning. On this basis it is proposed that the combined electrical stunning-cardiac arrest method is to be preferred, but, further investigations are required to establish whether it is associated with any defects in carcass quality.

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TABLE 4 Effect of 3 slaughtering methods on the time to less than 50% (t50) or 5% (t5) of the integrated spontaneous activity or excursion distance of the evoked response in the brains of ducks.

Slaughtering method	Spontaneous activity sec ± SE		Evoked activity	
	t50	t5	t50	t5
Cardiac arrest	6 ± 1^{a}	23 ± 3^{a}	38 ± 5^{a}	115 ± 7^{a}
Bilateral carotid arteries + bilateral jugular veins	23 ± 4^{b}	52 ± 9^{b}	81 ± 20^{b}	172 ± 28^{a}
Beak cut	80 ± 11^{c}	179 ± 16^{c}	240 ± 21^{c}	332 ± 21^{b}

Means in each column with different superscript letters were significantly different at least at p = 0.05 using the Mann Whitney test.