

A SOLUTION TO RESPIRATORY AND OTHER PROBLEMS CAUSED BY THE BIT

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SUMMARY

A physiological critique of the bit method of control led to the conclusion that it was contraindicated, counterproductive, and cruel. The evidence indicated that the bit constituted a welfare problem, a hazard to the health of horse and rider, and a handicap to performance. It has long been known that the bit has many pernicious effects on the horse's mouth but its wide-ranging and baleful influence on the respiratory, musculo-skeletal and nervous system has been overlooked. All the traditional bitless methods of control have limitations and disadvantages but a new method of bitless control was found to provide a physiologically acceptable and preferable alternative to the bit.

The findings are summarized as follows:

Digestive System

- The bit is an invasive method of control, as a body cavity is transgressed
- Bit-induced pain frequently causes loss of enthusiasm and even antipathy for exercise
- Aversion to the bit includes well recognized problems such as reluctance to be bridled; head shyness; buccal ulcers; wolf tooth sensitivity; pain during dental eruption; mandibular fractures; lacerations of the lip, tongue and gingiva; bleeding from the mouth; open mouth; constant tongue movement; the tongue being placed behind or over the bit; and an inclination for the horse to nullify the bit's control by gripping it between its premolar teeth.

- As the safety of horse and rider are imperiled when a horse takes the bit between its teeth and bolts, this constitutes a serious flaw in the bit method of control.
- The bit triggers a series of ‘eating’ responses that are diametrically opposed to those needed for rapid breathing at exercise. Galloping horses are neurologically confused by being signaled to ‘eat’ and ‘exercise’ simultaneously, two mutually exclusive activities.

Respiratory System

- Bit control depends primarily on atlanto-occipital flexion (poll flexion). This obstructs the nasopharyngeal airway. Hypoxia results and this leads to premature fatigue and reduced performance.
- Jowl angle at exercise reflects the status of the atlanto-occipital joint and, therefore, provides a rough measure of nasopharyngeal obstruction
- Evasion of the bit by retraction of the tongue causes elevation of the soft palate and, therefore, nasopharyngeal obstruction (‘swallowing the tongue’)
- It also causes dorsal displacement of the soft palate (‘flipping the palate’) and is considered to be the most common cause of this serious problem.
- The bit breaks what should be an airtight seal of the lips at exercise. Air invades the oropharynx and is yet another cause of dorsal displacement of the soft palate.
- Bit-induced nasopharyngeal obstruction causes inspiratory laryngeal stridor (‘roaring’) at exercise. This source of stridor should be considered in the differential diagnosis of recurrent laryngeal neuropathy and other obstructive diseases of the upper airway
- Bit-induced soft palate elevation is the most common cause of epiglottal entrapment
- Persistent bit-induced upper airway obstruction, together with other diseases such as recurrent laryngeal neuropathy, may in time be responsible for permanent tracheal stenosis (‘scabbard trachea’), a problem found to be much more common than previously reported
- As any obstruction of the upper airway is the cause of asphyxia-induced pulmonary edema (“bleeding”), the bit must take its share of blame for this widespread problem.
- If the hypothesis is correct that asphyxia-induced pulmonary hemorrhage results in inflammatory airway disease (AID), then the bit must be listed as a primary cause of AID
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Musculo-skeletal System

- As the bit interferes with breathing and as breathing at the gallop is synchronized with locomotion, it follows that the bit also interferes with the stride of the galloping horse
- A horse that flexes at the atlanto-occipital joint and ‘leans-on-the-bit’ loses self-carriage, and becomes heavier on the forehand. Its stride becomes shorter and, therefore, slower; a matter of some importance in racing.
- Forehand heaviness is incompatible with proper ‘collection’ and maximum hind-quarter impulsion
- Forehand heaviness places greater stress on the tendons, ligaments, joints and bones of the forelegs and, alongside premature fatigue caused by hypoxia, is a factor in the cause of sore shins, breakdowns and fatal accidents
- Resistance to the bit causes rigidity of the neck and a loss of that cervical freedom so indispensable to optimum performance. It reduces the efficiency of the natural swing of the head and neck pendulum which, in the wild, is an energy-saving device.
- Rigidity of the cervical spine leads to rigidity of the rest of the spine and this, in turn, destroys the natural fluidity of limb movement. The bit can be the cause, therefore, of poor action, a stilted gait, and stumbling. It also explains why the bit is sometimes the cause of a horse being unable to gallop in a straight line (‘veering’ or ‘lugging’).

Nervous System

- The bit is a well-recognized cause of acute pain in the mouth. Pain anywhere is a notorious source of reduced performance.
- The equine headshaking syndrome is compatible with bit-induced trigeminal neuralgia. Removal of the bit is the most rewarding treatment yet discovered for this recalcitrant problem

A new design of bitless bridle, that is neither a hackamore, bosal nor sidepull, permits full control that is pain-free and physiological. Known as the acupuncture bitless bridle, it is composed of a simple but subtle system of two loops, one over the poll and one over the nose. It controls in two ways. First, it stimulates acupuncture points behind the ear and over the poll. Secondly, it generates a benevolent headlock on the whole of the head.

It provides brakes by generating a ‘submit’ response from the horse that does not involve marked poll flexion and airway obstruction. It provides steering by pushing on one half of the head in a pain-free manner, rather than pulling focally on the highly sensitive tissues of the mouth.

The acupressure bitless bridle provides a humane, non-invasive and natural approach to horsemanship and, unlike the other bitless bridles, is applicable to both early and advanced schooling. The bridle has been tested by horsemen in nearly all branches of equitation and found to give almost universal satisfaction. User’s comments can be reviewed on the Internet at www.bitlessbridle.com

INTRODUCTION

Three years ago, I was invited by Allan Buck, a dressage instructor from Ramona, California, to evaluate a new design of bitless bridle that he had developed but was having difficulty in introducing to the horse owning public.¹ Recognizing that it provided satisfactory control and that horses emancipated from the bit exhibited rewarding improvements in behavior, attitude and performance, I began to ask myself what it is that the bit method of control really does to a horse, physiologically. This analysis led me to conclude that the bit:

- Is physiologically contraindicated
- Is a source of local pain in the mouth but also of trigeminal neuralgia affecting the whole of the face
- Impedes both grace and efficiency of performance
- Initiates resentment on the part of the horse and is a bar to the development of cooperation between horse and rider
- Encumbers horse and rider with many all too familiar bit-induced problems, which have been recognized for years by both veterinarians and horsemen.
- Furthermore, I concluded that there were many additional bit-induced problems that had not been recognized. It is now my opinion that the bit plays a role in the development of dyspnea due to upper airway

¹ ACUPRESSURE BITLESS BRIDLE™: ELG Inc., 206, Birch Run Road, Chestertown, MD 21620

obstruction, reduced performance, dorsal displacement of the soft palate, epiglottal entrapment, head shaking, scabbard trachea, asphyxia-induced pulmonary edema ('bleeding'), inflammatory airway disease, and many musculo-skeletal problems.

The purpose of this paper is twofold. First, to draw attention to these new explanations for old problems. Secondly, to introduce a new bitless method of control that is an acceptable and preferable alternative to the bit.

MATERIALS AND METHODS

The following critique of the bit was triggered by observing the physiological changes that occurred when the bit was removed. Results were drawn from riding the same horse, with and without a bit, using the new acupressure bitless bridle, and from studying others doing the same. These observations were supplemented, over a period of three years, with feedback reported by more than 100 users of the bitless bridle in almost every branch of equine activity, from the training of racehorses to riding for the handicapped.

The critique was based on a consideration of the first principles of equine respiratory physiology and, in particular, previous studies of the applied anatomy of the upper airway (Cook, 1981, 1982). Many texts on bits and biting were consulted, most of which were written by horsemen. It seems that very few veterinarians have contributed to the literature on this topic of fundamental importance to equitation (Cook, 1988; Clayton, 1999, Strickland, 1999). To the best of my knowledge, no one has previously commented on the fundamental physiological contradiction that is unavoidable with the bit method of control (Cook, 1999).

The effect on nasopharyngeal patency of tongue and jaw movement triggered by the bit was observed endoscopically, in the resting horse and during treadmill exercise.

Exercise trials were undertaken with horses that were known to be 'roarers', first with a bit in their mouth and then with the Acupressure Bitless Bridle.

A survey of tracheal conformation was carried out at a slaughterhouse.

Finally, various bits and bit combinations were weighed.

RESULTS

The bit is a well-recognized cause of problems in all branches of equitation. Many of these problems are so common that for centuries, and in each country of the world, the horseman's vernacular of phrases that describe these problems have entered the general language as metaphors for distinctive behavior in man. In the English language, for example, we speak of horses (and people) that 'get the bit between their teeth' and who are 'champing at the bit.'

In this article, I wish to focus on some 15 problems that have not previously been recognized as being caused by the bit. Nevertheless, for the sake of completeness, the more familiar problems should be listed first. Many are thought of as aberrations of behavior and are referred to by the umbrella term 'aversion to the bit', as though this was a reprehensible and unreasonable reaction on the part of the horse.

The list includes horses that resist being bridled, and others that, once bridled, constantly 'play with the bit', 'champ on the bit', grind their teeth, and froth at the mouth. At exercise, many horses open their mouths; put their tongue over the bit; grab the bit (i.e., clamp the bit between their premolars, "***controlling that by which they were controlled***"²); loll their tongues; toss their heads; lean on the bit; veer to one side (lugging in or out); pull hard against the bit and are designated as 'pullers' or as being 'hard-mouthed.'

It is widely accepted that pain from the bit can cause a horse to buck, rear and bolt. These serious problems are often attributed to the idiosyncratic behavior of individual horses or to misuse of the bit and are not generally admitted to be caused by a basic flaw in the bit method of control.

Complications associated with the bit include buccal ulcers (caused by the cheek pieces of a bitted bridle pressing the buccal mucosa against the sharp enamel edges of the cheek teeth); oral sensitivity associated with erupting permanent dentition; difficulties arising from the presence of 'wolf' teeth, and a number of other problems. Actual injuries and accidents recognized as

² Shakespeare: *Venus and Adonis*

being directly attributable to the bit include excoriations of the lips; bruising of the gums; lacerations and even amputation of the tongue; fractures of the mandible; and injuries to the hard palate.

So much for some of the familiar problems that are freely conceded to be caused by the bit. For the reasons given below, however, it is my opinion that the bit method of control must also be held responsible for 15 additional problems, now to be described.

1. The bit as a source of digestive system responses that are inappropriate in an exercising horse

In common with all mammals, horses have evolved to either eat or run. They are not equipped to do both simultaneously. The anatomical crossover of the digestive and respiratory pathways at the level of the pharynx dictates that the two activities are mutually incompatible (Figs 1-3). And yet this is what we have been expecting of a horse for the past 6000 years.

As soon as a bit is placed in the mouth, the horse is being signaled, physiologically, to 'think eat'. Accordingly, the seal of the lips is broken, and reflex salivation commences, together with movement of the lips, jaw and tongue. These are digestive system responses, dominated by the parasympathetic nervous system.

But now a rider mounts and asks for motion. As a result, the horse is being signaled to 'think exercise'. Accordingly, an entirely opposite set of 'fight and flight' reflexes are initiated, dominated by the sympathetic nervous system. From this I conclude that, at exercise, the horse suffers from neurological confusion, as its nervous system is trying to respond to two conflicting requirements, each tugging in the opposite direction. A horse can either graze or gallop but it should not be expected to do both at the same time. In sum, the bit method of control initiates a set of responses that are diametrically opposed to those required for exercise. Eating and exercising are two mutually exclusive activities.

- For eating, the horse needs to salivate and therefore has a wet mouth (parasympathetic)
For galloping, salivation should be in abeyance and the horse should, contrary to traditional teaching, have a relatively dry mouth (sympathetic)

- For eating, the horse needs to be in a relaxed frame of mind, dominated by cholinergic responses
For galloping, it needs to "... stiffen the sinews, summon up the blood ... set the teeth, and stretch the nostril wide",³ a state of mind dominated by adrenergic responses
- For eating, the horse needs an open mouth and it is physiological for there to be some air in the oral cavity and oropharynx.
For galloping, its lips should be sealed and there should be no air in the oral cavity. The presence of air constitutes a hazard. Because of the orientation of the head, air will tend to creep upwards and invade the oropharynx. This process will be encouraged by tongue and jaw movement. Air now breaks what should be a natural seal between the root of the tongue and the soft palate. Dorsal movement of the soft palate on its cushion of air will cause stenosis of the nasopharynx and the galloping horse may develop inspiratory stridor (become 'thick in its wind' or a 'roarer'). Once air is present ventral as well as dorsal to the soft palate, the aerodynamic conditions are favorable to the development of soft palate vibration during galloping. This will be especially likely to occur if the head is flexed (as when the horse is being 'rated') and the soft palate is no longer under longitudinal tension (Fig 4-5). The soft palate may start flapping like a wet blanket in the wind and the vibration may become audible ('gurgling'). Subsequently the soft palate may become dislocated from the ventral half of the ostium intrapharyngium (dorsal displacement of the soft palate) and the horse will asphyxiate ('choke-up') (Fig 6).
- For eating, the horse needs a mobile jaw, tongue and lips
For galloping, all these structures should be immobile
- For eating (swallowing), the horse needs a mobile and dorsally elevated soft palate (Fig 3)
For galloping it needs an immobile and ventrally placed soft palate (Fig 2)
- For eating, the horse enlarges its oropharynx at the expense of the nasopharynx
For galloping it enlarges the nasopharynx at the expense of the oropharynx
- For grazing or drinking, the wild horse needs its neck and head to be lowered, its muzzle at ground level, and its atlanto-occipital joint fully extended. The respiratory rate will be 8-12/minute, the minute volume

³ Shakespeare, *Henry V*

will be minimal and there will be no respiratory/locomotor coupling. Under these conditions, grass can be chewed into a semi-liquid stream which flows easily into the patent oesophagus via the lateral food channels (laryngopharynx), while the rima glottidis of the larynx remains open in the resting position. There is no interruption of respiration and the olfactory sense remains functional to warn of predators. Water is drunk in rhythmic boluses that require the rima glottidis to be intermittently but transiently closed. This and the force of gravity ensures that no water enters the lungs.

For galloping at maximum speed, its head and neck should be elevated and its atlanto-occipital joint in full extension. The rima glottidis should be fixed in the fully abducted position and the cricopharyngeal sphincter guarding the entrance to the esophagus should be closed. The respiratory rate is hugely increased to 120-140/minute, with a concomitant rise in minute volume.

Some of the problems described below are actually specific instances of the general conflict caused by the bit stimulating a series of inappropriate digestive system responses during exercise.

2. The bit as a cause of counterproductive poll flexion

The bit method of control allows a large mechanical advantage to be applied to the most distal part of the head, by means of focal pressure on the sensitive oral cavity. A characteristic feature of the restraint applied for the purpose of braking is, therefore, marked atlanto-occipital flexion (Figs 4-5). As explained above, such a position of the head is incompatible with an unobstructed airway. It follows that the bit method of control brings about its braking effect through a process of partial asphyxiation. Any position of the atlanto-occipital joint other than full extension implies a degree of upper airway obstruction for a galloping horse.

It is a paradox of racing, when using the bit method of control, that jockeys are holding their horses in, by flexing their atlanto-occipital joints and, therefore, partially asphyxiating their mounts in the first two thirds of most distance races.

Another phenomenon caused by bit-induced poll flexion is the 'high-blowing' or 'trumpeting' that occurs in a fresh horse that is being given its first canter of the morning. When a keen horse is held in, air turbulence

generated in the obstructed nasopharyngeal airway produces, on expiration, a characteristic noise caused by vibration of the nasal diverticulum. In itself, I have never previously thought of this noise as being of any clinical significance, as airway obstruction during expiration is so much less important than on inspiration. However, I now realize that, even though the horse is not generally making a noise on inspiration, nevertheless the expiratory noise should be taken as a warning that the airway is being obstructed on inspiration also. If fast exercise is continued with the horse's head in this overbent position, undoubtedly the lungs will be damaged by barotrauma (Fig 4B). Later in this article it will be explained how this occurs, in the section on asphyxia-induced pulmonary edema ('bleeding'). For the present it is enough to note that racehorse trainers who habitually exercise their horses in draw reins or permit their exercise riders to hang back on the bit and haul on the head, are not doing their horse's lungs or their mouths a favor (Fig 5). 'Bleeding' is a problem that is often more severe during training periods than it is during an actual race, and poll flexion is the reason.

3. The bit as a cause of contraindicated movement of tongue, soft palate and larynx

Endoscopy at rest and on the treadmill, with and without a bit in the horse's mouth, demonstrated that tongue movement is much more active when a bit is present. It also revealed that the slightest tongue movement resulted in a dorsal movement of the soft palate (not necessarily a displacement) and that this, in turn, resulted in nasopharyngeal stenosis and transient periods of complete obstruction.

The tongue is suspended from the base of the skull by the hyoid apparatus and shares this same suspension with the larynx (Fig 8). It follows that any major shifts of the tongue will also result in a shift of the larynx. Once again, this is confirmed by endoscopic observation. If, for example, we wish to get an uninterrupted view of the larynx for the purpose of evaluating recurrent laryngeal neuropathy, we know that we cannot do this if a horse still has a bit in its mouth. Even at rest, under these conditions, the larynx shifts about like a ship in a storm. At exercise, the 'storm' is even worse, as can be shown by trying to 'scope a horse on the treadmill with a bit in its mouth. From an aerodynamic point of view, this constant juddering of the

airway at fast exercise has to be regarded as incompatible with and an impediment to efficient airflow.

Racehorse trainers attempt to counter the unwelcome tongue movement by tying the tongue to the lower jaw. By so doing they add yet one more foreign body and source of pain for the horse to suffer, whereas the logical way to reduce tongue movement is to remove the bit.

4. The bit as the cause of dorsal displacement of the soft palate

Dorsal displacement of the soft palate is a normal though transient part of swallowing but a disastrous thing to happen during fast exercise (Fig 6). Horses are described variously as having ‘choked-up’, ‘gurgled’, ‘swallowed their tongue’ or ‘flipped their palate’. It is currently my opinion that the most common cause of this phenomenon is the presence of a foreign body, the bit, in the oral cavity. There are at least four possible explanations.

First, any movement of the tongue or jaw causes movement of the soft palate. Any such mobility of the soft palate could, by itself, precipitate dorsal displacement.

Because of the respiratory/digestive conflict that the bit induces, we should I think give credence to the possibility that some horses experience gagging reflexes at exercise which precipitate spasm of the throat. From our own experience, we know that gagging reflexes are readily precipitated by the pressure of a spatula on our tongues when having our tonsils examined and that some of us are far less tolerant of such procedures than others.

The presence of large quantities of saliva, induced by the bit, in the oropharynx of a galloping horse may well precipitate an involuntary and inappropriate swallowing reflex. The soft palate will displace and be the cause of immediate and major airway obstruction (Fig 3). Once the soft palate has become displaced dorsally in a galloping horse, the rapid flow of air prevents it being returned to its proper position below the epiglottis. The horse now ‘chokes-up.’

A fourth source of soft palate displacement is the presence of an air bubble in the oropharynx, tending to lift the soft palate and also causing it to vibrate. A bit breaks the normal seal of the lips at exercise and even causes the mouth to be pulled open (Fig 10). Either of these things permit air to

gain access to the oral cavity. Once present, the shifting about of the tongue, coupled with the natural tendency for gases to rise, will result in air gaining access to the oropharynx. When air is present on both sides of a blanket of tissue, the stage is set for a blanket to start flapping in the breeze. In a galloping horse, there is already a gale force wind blowing on the dorsal side of the soft palate 'blanket'. It is surely not to be wondered at when air enters the oropharynx and now lies ventral to the soft palate as well that dorsal displacement occurs.

5. The bit as the cause of epiglottal entrapment

It is my opinion that the oropharynx of the galloping horse, in the wild, should not contain any air. During exercise it should be a potential space only (Fig 2). It should be sealed off from any communication with the upper airway by the air-tight integrity of the ostium intrapharyngium or 'button-hole' of the soft palate. Any situation that results, during exercise, in a loss of the airtight seal separating the oropharynx from the nasopharynx is, I believe, the cause of epiglottal entrapment. Under these conditions, the abundant and highly mobile mucosa of the oropharynx is unnaturally exposed to the drag effect of a negative ambient pressure generated in the airway during inspiration (Fig 7). The result is that the pliable elastic mucosa on the ventral face of the epiglottis and in the vallecula, the floor of the oropharynx, gets dragged caudally, in the direction of the lungs. It is this mucosa that now enshrouds the epiglottal cartilage and constitutes what we call epiglottal entrapment.

The above mechanism explains why epiglottal entrapment is observed as a sequel to cleft of the soft palate in those few horses that survive to the point of being schooled for exercise. However, a much more common cause of a leaky ostium intrapharyngium is the soft palate elevation generated by the bit, in any one of the four ways explained above.

6. The bit as the cause of laryngeal stridor

A two year old Thoroughbred filly that had made an abnormal inspiratory noise since first being schooled was examined at rest and found to have no more muscle wasting in the left side of her larynx than average. On endoscopy, there was no evidence of advanced recurrent laryngeal neuropathy and this was confirmed by a nerve conduction test using the electrolaryngeograph (Cook, 1999). Yet, even at slow exercise she made a

significant inspiratory noise and, immediately after exercise, palpation of the larynx revealed considerable fremitus. The snaffle bit was now removed and, ten minutes later, the filly was exercised again in the Acupressure Bitless Bridle. The laryngeal stridor was no longer present and post-exercise fremitus was no longer detectable. The rider reported a marked improvement in her gait and in her attitude to exercise. I concluded that the inspiratory noise was caused by nasopharyngeal obstruction, triggered by avoidance of the bit.

The above case record is typical of others. In the past, I have been of the opinion that the most common cause of an abnormal inspiratory noise at exercise was recurrent laryngeal neuropathy. In future, before assuming in any one case that recurrent laryngeal neuropathy is the cause of 'roaring', it is now my opinion that the bit as an etiological factor should first be excluded.

7. The bit as the cause of interference with locomotor/respiratory coupling:

The concept of locomotor/respiratory coupling at fast paces is now familiar. A galloping horse takes one stride for every breath (Cook, 1965).⁴ It follows from this principle, that anything which interferes with breathing, must also interfere with striding. In the preceding sections, evidence is advanced to explain the many ways in which the bit interferes with breathing. For example, the bit causes tongue movement. This results in dorsal displacement of the soft palate, which lies on the root of the tongue. Dorsal displacement of the soft palate results, in turn, in obstruction of the nasopharyngeal airway. There are many other cascade effects but this one example will suffice for the present. I conclude, therefore, that the bit must, by definition, interfere with the normal rhythm and grace of the stride.

As already mentioned, the bit method of control allows a rider to flex a horse's neck at the poll. This is how brakes are applied and a racehorse is 'rated'. Flexion of the poll, however, is another way in which the upper airway is obstructed and this, in turn, must have an effect on the stride.

8. The bit as a source of interference with a horse's balance and natural grace of movement

⁴ THIS CONCEPT WAS FIRST REPORTED IN GERMANY BY WITTKE IN, I THINK, 1959 AND EXPANDED ON, AGAIN IN GERMANY, BY HORNICKE IN 1965. BUT I REGRET THAT I DO NOT HAVE THE CORRECT REFERENCES TO HAND

Poll flexion also interferes with the stride by 'locking-up' the neck. The natural reaction of a horse to the leverage force applied by a bit on its mouth is to resist this force by means of tension in the cervical musculature. But tension in the neck is incompatible with free movement of the legs. If the neck is abnormally rigid, so is the rest of the spine, and this - in turn - will impede the free movement of the limbs. No human athlete could perform well with his or her neck in plaster.

I assume that horses are seeking to partially negate the effect of the bit, when they place their tongue over the bit. This probably allows them to stabilize the bit to some extent and, though it must still be a source of pain in the lower jaw, at least it prevents the bit from clashing up against the teeth or hitting them in the roof of the mouth. With the bit securely 'captured' under the tongue and being pulled against the frenum of the tongue, the horse now 'leans on the bit.' This, in turn, results in their balance being further upset, over and above the unbalancing that is brought about in other ways, under domesticity, by the presence of a rider or the drag of a cart, carriage or sulky. Horses that 'lean on the bit' or, for similar reasons, grip the bit between their teeth, become abnormally 'heavy on the forehand.' Interference with the normal balance of the galloping horse has a harmful effect on the stride. It also places extra strain on the forelegs and is likely to be a factor in the etiology of such familiar problems as sore shins, foreleg lameness and breakdowns.

The combined effect of the above constraints leads in some horses to the onset of stumbling. Experience with the Acupressure Bitless Bridle has shown that many a stumbler no longer does this if the bit is removed.

9. The bit as a weight handicap

There is another cause of heaviness on the forehand which has, I believe, been overlooked. I refer to the unbalancing effect of the bit's weight. Bits range in weight from a pony-sized snaffle at 180g (6 ozs) to the combined weight of the bits and curb chain for a horse's double bridle at 780g (26 ozs). If one adds to these weights the weight of the bridle necessary to suspend the bits in the mouth, the total dead weight we place on the most rostral extension of the horse's balance arm, is considerable.⁵ Yet this weight must

⁵ The bridle and bits for a Standardbred racehorse weighs in the region of 2.8 Kg (6lbs)

be immeasurably increased by even the slightest traction on the reins (Fig 5). The total effect is to make horses 'heavy on the forehand'.

10. The bit as a device that causes premature fatigue

Neck restraint brought about by the bit interferes with the vertical swing of the head and neck pendulum in the galloping horse. In racing parlance, this swing is known as 'the head bob.' As the swing is an energy saving device (Fig 11), it follows that the bit results in a waste of energy and is, therefore, a cause of premature fatigue and reduced performance.³

11. The bit as a cause of tracheal deformation ('scabbard' trachea)

A slaughter house survey of tracheal conformation in the horse supported my previous impression that 'scabbard trachea' (Fig 12) was far more common than currently believed. The frequency of tracheal distortions of many kinds was not only much higher than reported but it also occurred in a much wider breed distribution than previously recognized. In agreement with others, I had previously supported the concept that 'scabbard trachea' was a problem most likely to be encountered in the pony and the miniature horse. But the survey indicated that it was also extremely common in the Thoroughbred and other breeds. At the time of the survey I was unable to explain the cause of this finding, though I toyed with the explanation that it was caused by some inherent weakness of cartilage. Since recognizing how frequently the collective effects of the bit, together with recurrent laryngeal neuropathy, and poll flexion cause upper airway obstruction, I have come to believe that 'scabbard trachea' could be the long-term effect of this obstruction. Persistent upper airway obstruction at fast exercise could result in dynamic collapse of the dorsal tracheal membrane and, in time, this might distort the tracheal cartilages and produce the marked dorso-ventral flattening of the trachea that is so commonly seen at autopsy. At this stage of my career, I am content to put this explanation forward as a hypothesis for others to test.

12. The bit as a cause of asphyxia-induced pulmonary edema

For many years I have supported the hypothesis that so-called exercise-induced pulmonary hemorrhage ('bleeding') in the horse is caused by upper airway obstruction (Fig 8) (Cook, Williams, Kirker-Head and Verbridge 1988, Cook 1997). Three years ago I would have said that the most

common source of this obstruction was recurrent laryngeal neuropathy but I now realize that the bit represents another ubiquitous source of airway obstruction (Figs 13-14). Whatever the relative roles are, I am convinced that the bit, as a management factor, should certainly be considered alongside inherited diseases such as recurrent laryngeal neuropathy and acquired conformational defects such as deformities of the trachea, to have a role in the cause of this widespread problem.

13. The bit as a cause of inflammatory airway disease

In recent years, much has been written about a lower respiratory tract disease seen, in particular, in younger racehorses in training. This has in the past been referred to as chronic obstructive pulmonary disease (COPD) but the inflammatory changes observed are less severe than the typical COPD or 'heaves' of the older horse and it shows no evidence of progression to the classical picture of 'heaves' as the racehorse ages (Robinson, 1999). It has been suggested that this disease should be called inflammatory airway disease (Moore, 1996) but the cause of the disease has not been satisfactorily explained.

I support the hypothesis that at least one cause of AID is as a sequel to asphyxia-induced pulmonary edema. Red blood cells are an irritant in the interstitial tissues and small airways of the lung and it seems likely that repeated episodes of 'bleeding' would produce the low grade inflammatory responses that are detected by bronchoalveolar lavage and are associated with the presence of abnormal quantities of bronchial mucus. If this hypothesis stands up to testing, then the bit would have to take its share of etiological blame for inflammatory airway disease.

14. The bit as a source of pain and an inhibitor of maximum performance ('heart')

The bit is undoubtedly a source of pain, both acute and chronic. The long-term effect of chronic pain on the respiratory system will be addressed in the following section on the headshaking syndrome. Acute pain in the horse is likely, I would suggest, to have similar effects on respiration in the horse as it does in ourselves. In other words, to be the source of momentary interruptions in respiratory rhythm and, when we "*draw our breath in*

*pain*⁶, a general mental unwillingness and inability to perform to a maximum athletic potential.

The bit method of control results in the rider applying his or her greatest force to one of the most sensitive and potentially painful parts of the horse, its mouth. This is a body cavity and massively innervated by somatic sensory nerves (Fig 15). Using a surgical analogy, it can be said that the bit is an invasive method of control.

The bit is a well-known source of acute pain and responsible for a number of responses such as rearing and bolting. Either of these may be a horse's response to being hit in the mouth by the bit. Neither rearing or bolting should be labeled as a vice until all possible man-made causes have been eliminated; in particular the pain from a bit or from an ill-fitting saddle.

Bit-induced pain can result in the horse disarming the bit by gripping it between upper and lower premolars. The horse now controls that by which it was previously controlled. The rider is no longer in control and the horse may bolt in any direction. The possibility of such a radical evasion of the bit constitutes a dangerous flaw in the bit method of control.

The bit method of control may also cause pain during the three years in a horse's life, from two to five, when its oral cavity is already sensitive because of erupting permanent dentition. Unfortunately, this period coincides with the precise period during which racehorses are intensively employed.

The presence of unerupted first premolars ('wolf' teeth in the lower jaw represents another source of pain and one that may not be suspected. The bit rides over the bars of the mouth in just exactly the place that these vestigial first premolars are located. Wolf teeth in the upper jaw are more apparent and are frequently removed but we should probably be more concerned about the wolf teeth in the lower jaw.

A scourge is defined as an instrument of punishment and the term is particularly apt when applied to the bit's potential for bruising the gums, excoriating the lips, lacerating the tongue, ulcerating the buccal mucosa, and

⁶ *THE PROBABILITY HAS BEEN OVERLOOKED THAT ASPHYXIA-INDUCED PUMONARY EDEMA CAUSES A HORSE CONSIDERABLE PAIN*

generating star fractures of the mandible at the diastema. Racehorses and Western cutting horses are commonly found to be bleeding from the mouth after exercise. A trainer may, at any one time, have 20% of his horses with 'sore mouths.' Collectively these injuries to the extremely sensitive mouth must be a source of severe pain. Manifestations of pain may be exhibited in a number of ways. At rest, the horse may show loss of appetite, an aversion to being bridled, constant 'mouthing', grinding of the teeth, and excessive salivation or slobbering. At exercise, pain may be responsible for an open mouth (yawing), veering (lugging to one side), tongue lolling, pulling, bolting, rearing, head tossing and a general lack of enthusiasm for peak athletic performance.

15. The bit as a cause of headshaking

The preceding paragraphs all refer to localized pain in the mouth. A feature that has not been recognized is the bit's role as a source of more widespread and persistent pain in the form of neuralgia. As a result of clinical evidence collected over the last three years, I am now of the opinion that constant pressure from a steel bit on the mouth and mandible, triggers trigeminal neuralgia (Cook, 1999). Pain in the mandibular branch of the fifth cranial nerve is, I propose, referred to other branches of this major sensory nerve and is frequently responsible for the familiar clinical signs that are a feature of the head-shaking syndrome (Fig 15). Apart from head shaking, these include other neurological signs such as head rubbing, blephorospasm and photophobia; and respiratory signs such as sneezing and snorting. In addition there are musculo-skeletal signs such as stumbling and a loss of the normal fluidity of gait. Together these effects result in a horse's inability to focus on the task in-hand and often render it useless for any further work (Cook, 1979). The seasonal nature of this syndrome can, I think, be explained without necessarily resorting to the assumption that this is an allergic rhinitis, as symptoms of trigeminal neuralgia in man are exacerbated by warm weather or bright sunlight.⁷

Removal of the bit should, in my opinion, be the first step in the clinical work-up of these difficult cases. The validity of a tentative diagnosis of trigeminal neuralgia can be judged by a rewarding response to elimination of the trigger factor.

⁷ Having been kicked in the maxilla by a horse many years ago, I can vouch for this from personal experience of trigeminal neuralgia.

CONCLUSIONS

The various body systems are interdependent and it is difficult to separate out the effect of the bit on each, without considerable overlap. Nevertheless, by way of summarizing the situation, the following rough classification can be proposed.

With regard to the bit's effect on the respiratory system, I conclude that it is :

- A cause of upper airway obstruction, and therefore, premature fatigue and poor performance. In my opinion, it can have this effect even in horses that make no audible inspiratory noise.
- A common cause of abnormal inspiratory stridor at exercise ('roaring' and general 'thickness of wind') associated with elevation of the soft palate.
- A common cause of dorsal displacement of the soft palate ('gurgling' and 'choking-up'), due to a combination of tongue retraction, poll flexion, the presence of air in the oropharynx and the occurrence of pharyngeal spasm induced by gagging reflexes and abortive attempts to swallow saliva during exercise.
- The prime cause of epiglottal entrapment; because the soft palate elevates and exposes the flaccid mucosa of the oropharynx to an abnormally high negative pressure on inspiration.
- A cause of asphyxia-induced pulmonary edema ('bleeding'). This conclusion follows because of the established upper airway obstruction.⁶
- A cause of the inflammatory airway disease (small airway disease) that follows repeated episodes of asphyxia-induced pulmonary edema.⁶

With regard to the bit's effect on the musculoskeletal system, I conclude that it is:

- A cause of heaviness on the forehand and stumbling and, therefore, a contributory factor in the pathogenesis of sore shins, and forelimb tendon/ligament strains, joint injuries and fractures
- A cause of a general stiffness of gait and loss of that fluidity of motion characteristic of the horse at liberty
- A source of disruption in locomotor/respiratory coupling

With regard to the bit's effect on the nervous system and the horse's general attitude to exercise, I conclude that it is:

- A source of acute and chronic pain in the mouth

- A cause of trigeminal neuralgia and the headshaking syndrome
- A cause of a general loss of enthusiasm for exercise and that precious but intangible quality known as ‘heart.’

ALTERNATIVE BITLESS METHODS OF CONTROL

Bitless methods of control have a longer history than the bit but they have not been so universally adopted. Today, they comprise control by use of the Hackamore, the bosal and the sidepull. All of these have limitations and disadvantages. The primary disadvantage is that they all depend on poll flexion for the application of restraint and they work primarily by means of pressure across the nose. The hackamores and the bosals provide brakes, but are weak on steering. The hackamore has the additional disadvantage of being potentially painful and even dangerous in the wrong hands. Sidepulls are better on steering than the others but are weak on brakes.

The Acupressure Bitless Bridle

This bridle works on a different principle from all the bitless methods mentioned above. Essentially it controls by two loops; one over the poll (the primary control) and one over the nose (Fig 16).

Braking is effected by traction on both reins, which allows the rider to embrace the whole of the head in a benevolent headlock. Pressure is distributed evenly over the whole of the head and the amount of pressure at any one point is slight. It amounts to nothing more than a gentle squeeze. Nevertheless, this inoffensive pressure may be enough to stimulate a cluster of acupressure points at the poll and behind each ear. The total effect seems to trigger a 'submit' response from the horse and provide effective brakes.

Traction on one rein (Fig 16: open arrow) pushes inoffensively on the opposite half of the head (Fig 16; solid arrows) and provides excellent steering. Where the head goes, the horse follows. Because the whole of the head is involved in the response to pressure, the turn of the head is more natural than that invoked by a bit through focal pressure on the mouth. Whereas the bit pulls on a small area of highly sensitive and potentially painful tissue, the acupressure bridle pushes on a large area of relatively insensitive skin. As horses respond better to being pushed than pulled, this is another advantage of the bridle.

A great deal more could be written about this new method of control but at this point I wish to declare a conflict of interest, as I am now marketing this bridle. I hope that my evaluation of the bridle as a significant contribution to the welfare of the horse will not be viewed askance because of my commercial connection. Nevertheless, for this reason I will not subject readers to my own description of the results achieved with the bridle. Rather I will leave readers to review the 70 or more pages of mostly unsolicited testimonials that comprise the 'User's Comments' section of my website.⁸ By so doing, readers may judge for themselves on the basis of evidence that, though anecdotal, is nevertheless extraordinarily compelling.

DISCUSSION

The pathophysiological effects of the bit method of control, on three major body systems crucial to athletic performance have not previously been considered. It has been widely assumed that it is perfectly alright to place one or more bars of metal in the horse's mouth and to use these as a fulcrum for leverage. The bit method of control has been in use for 6000 years and we have all become so accustomed to the bit that we have failed to question the fundamentally inappropriate nature of the method, and even to acknowledge its basic cruelty. These things have perhaps been overlooked because of the bit's time-honored place in history but also, it has been admitted, because of the lack of any truly satisfactory alternative. Nevertheless, it must be one of the few pieces of technology that have survived unchanged since the Bronze Age. The summary conclusions of the critique are that the bit method of control is:

- incompatible with the welfare of the horse
- physiologically contra-indicated
- conducive to accidents and hazardous to the health of horse and rider
- counter-productive in terms of equine athletic performance

An unexpected number of bonuses resulted from considering what the physiological effect was of placing a foreign body in the mouth of a running horse. It was realized, for example, that the presence of a bit initiated a

⁸ www.bitlessbridle.com

fundamental physiological incompatibility. Horses, no more than any other mammals including man himself, had not evolved to eat and exercise concurrently. From recognition of this fundamental principle of physiology, much else followed.

For example, it shed new light on a number of familiar but troublesome problems, the cause of which had previously been unknown or unsatisfactorily explained. It is now proposed that inspiratory stridor at exercise is commonly caused by the bit and that the bit should be considered as a differential diagnosis for recurrent laryngeal neuropathy and other common causes of upper respiratory obstruction. Having said that, it is further proposed that two of the other more common phenomena resulting in upper respiratory obstruction are also caused by the bit. I refer to dorsal displacement of the soft palate and epiglottal entrapment. Furthermore, evidence that I have previously published which supports the hypothesis that asphyxia-induced pulmonary edema ('bleeding') is caused by any upper airway obstruction, now gains further strength.⁶ Whatever it is that causes 'bleeding' has to be extremely common (such as recurrent laryngeal neuropathy) because 'bleeding' itself is so common. So now we have another universal factor to consider. All Thoroughbreds and most other racehorses wear bits. The bit causes upper airway obstruction and it follows that the bit must now be considered as a common cause of 'bleeding'.

A most satisfying bonus to me, as someone who has puzzled unsuccessfully for years about the cause of headshaking in the horse, was to finally uncover a satisfying explanation for the head shaking syndrome. It dawned on me that all the many and varied clinical signs exhibited by headshakers were compatible with the presence of bit-induced trigeminal neuralgia (tic douloureux). Such an etiological hypothesis was readily put to the test and confirmed by the simple expedient of removing the bit. Banishing the bit may not cure every headshaker overnight, but many respond most gratifyingly and it is certainly the most rewarding treatment for this recalcitrant problem that I have yet encountered.

A final bonus was to realise that removal of the bit improved a horse's balance and took weight off the forehand. It is reasonable to argue from this premise that removal of the bit might well reduce the incidence of sore shins, foreleg lameness and breakdowns of all sorts.

A brief review of the three bitless methods of control that have been available until recently, draws attention to the fact that, though all of them have considerable merit by comparison with the bit, none of them are entirely satisfactory. The hackamore is potentially harmful to the horse and neither the Hackamore nor the bosal provide adequate directional control.

The paper draws attention to a new bitless method of control known as the Acupressure Bitless Bridle. This bridle provides better control than the bit; is physiologically compatible with fast exercise; kinder to the horse; safer and more rewarding to the rider. Using the acupressure bitless bridle, many a horse that has been classified as difficult or even dangerous to ride, has been found to become compliant and cooperative. The new bridle permits riders to develop the partnership and harmony with their horse that has been the aim of good horsemen since the time of Xenophon. For further information on the new bridle and for feedback on practical results from a large cross-section of owners and trainers, readers are referred to a website.

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CAPTIONS

Fig 1. Showing the switching processes needed to change pharyngeal function from exercising to eating. For the sake of clarity, the mouth, oropharynx and esophagus are shown as actual spaces. However, except for those times when they contain food or liquid, these are - in normality - potential spaces only.

Key: OP = ostium intrapharyngium; E = epiglottis; AC = arytenoid cartilages; NP = nasopharynx; OP = oropharynx; L = larynx; LP = laryngopharynx; EP = esophageal pharynx

a) Exercising: The soft palate is lowered to seal off the oropharynx and enlarge the nasopharynx. The arytenoid cartilages are raised to close the esophagus and open the larynx. The epiglottis is lowered to form a seal with the soft palate and, more than is apparent in this diagram, to smooth off the airway. The larynx now fits snugly into the ostium intrapharyngium or 'button-hole' of the soft palate.

b) Eating dry food or swallowing liquids: The soft palate is raised to close off the nasal cavity at the nasopharyngeal sphincter and prevent food or water from refluxing into the nasal cavity . The arytenoid cartilages swing down to open the esophagus and close the larynx, so preventing food or liquid from inundating the lungs. Finally, the epiglottis swings back over the arytenoid cartilages.

Fig 2. Showing the anatomical relationship of the soft palate and the larynx for exercise. The larynx should fit tightly into a 'button-hole', the ostium intrapharyngium, in the soft palate. There should be an airtight seal between the two so that no air gets into the digestive tract, i.e., the oropharynx. If it does, then the soft palate rises and starts to vibrate (Fig 6).

a). Neutral poll position (jowl angle 87°): Note the position of the bit in relation to the tongue and soft palate. The double-ended arrow indicates the direction of airflow.

b). Full poll extension (jowl angle 150°): An enlarged view of the pharynx in Fig 2a, showing the elastic 'button-hole' of the soft palate in perspective and the ideal airway for galloping.

Fig 3. Showing the anatomical relationship of the soft palate and larynx at the moment of swallowing dry food or drinking.

a) The soft palate is completely 'unbuttoned' from the larynx and no longer embraces either the epiglottis or the arytenoid cartilages.

b) An enlarged view of the pharynx in fig 3a, showing how the button hole of the soft palate collapses when no longer stretched by the larynx. It now forms part of the nasopharyngeal sphincter as a bolus of food or liquid is passed into the open esophagus.

Fig 4. Showing the correlation between patency of the upper airway and the position of the atlanto-occipital joint.

Key: Dense black areas = bone or cartilage; cross-hatched areas = soft tissues

a) Full atlanto-occipital extension (jowl angle 140°): The airway is fully patent. The soft tissue boundaries of the nasopharynx are stretched longitudinally, which helps them resist the otherwise collapsing force of inspiration. The larynx lies caudal to the vertical ramus of the mandible.

b) Partial poll flexion (jowl angle 70°): The airway is sharply bent and seriously obstructed. The soft tissues of the pharynx collapse further into the airway during inspiration (see broken lines and arrows). The entrance to the larynx and the arytenoid cartilages lie between and are cramped by the vertical rami of the mandible. If, as in dressage, the horse works with its

nasal bone vertical to the ground or, even worse, behind the vertical ('overbent'), the degree of airway obstruction would be even more severe. The larynx would now lie totally between the rami of the mandible. It would be as though the pharynx and larynx were rammed into each other on a longitudinal axis. The walls of the nasopharyngeal airway would be folded like the compressed bellows of a concertina and the entrance to the larynx would be shrouded.

Fig 5. Showing a not uncommon sight during morning training periods on the racetrack in the USA. This diagram, taken from a photograph, shows an exercise rider standing in the stirrups in an effort to control ('rate') his horse, throwing the whole of his body weight backwards. In the meantime, the horse is galloping hard with with many pounds per square inch of pressure on its mouth; with its atlanto-occipital joint strongly flexed; and its nasopharyngeal airway obstructed.

Fig 6. Showing the turbulent airflow that results when the soft palate becomes dorsally displaced during fast exercise..

a). The arrows indicate how, once the palate is raised, air enters the oropharynx at each expiration. This maintains the problem until such time as the horse can slow up and swallow. During inspiration, the soft palate would rise even further towards the roof of the nasopharynx. This further narrows the airway but it also has the effect of exposing the oropharynx to the negative pressure of inspiration, an effect of interest in relation to the cause of epiglottal entrapment.

b). An enlarged view of the pharynx in Fig 6(a), showing the soft palate button-hole in perspective. Because the button-hole is elastic, its aperture shrinks when it is no longer dilated by the larynx. The airway becomes severely compromised.

Fig 7. Two lateral views of the soft palate and its relationship with the oropharynx and the epiglottis to illustrate the causal mechanism of epiglottal entrapment.

a) Normal: The soft palate occupies the potential space of the oropharynx, making an airtight seal with the laryngopharynx. It effectively separates the oropharynx from the nasopharynx and prevents the oropharyngeal

mucosa from coming under the influence of a negative atmospheric pressure during inspiration.

- b) Abnormal: For the sake of the illustration, the situation shown is that of a cleft palate but the principle applies equally to dorsal displacement of the soft palate. In both problems, the oropharynx and nasopharynx are in communication. During inspiration, the freely mobile and abundant mucosa on the ventral face of the epiglottis comes under the influence of a strong negative pressure and is dragged caudally to entrap the epiglottis in the manner shown. Elevation of a normal soft palate produces the same effect, as it allows the oropharynx and nasopharynx to be in communication.

Fig 8. Showing how the larynx and tongue are both suspended from the base of the skull by the hyoid apparatus. As both share a common anchorage, any bit-induced movement of the tongue causes a movement of the larynx, which in turn interferes with the free flow of air through the larynx. As the root of the tongue is in contact with the soft palate, tongue movement also causes elevation of the soft palate and stenosis of the nasopharynx.

Fig 9. The pathophysiology of “swallowing the tongue”. If a horse evades the bit and retracts its tongue behind the bit, the root of the tongue pushes the soft palate dorsally (obstructing the nasopharynx) and pushes the epiglottis caudally (obstructing the entrance to the larynx). Air turbulence is generated in the larynx and the horse may develop laryngeal stridor on inspiration. If the obstruction progresses, the horse may choke up and partially asphyxiate.

Fig 10. . Showing how dorsal displacement of the soft palate may occur when a horse opens its mouth in response to bit traction, allowing air to enter the oropharynx. This results in dorsal elevation of the soft palate and the sequence of events already described.

Fig 11. Showing the three main phases of one stride in a horse that is galloping at liberty and has freedom of its neck. Under these circumstances, the natural swing of the head and neck pendulum (the head bob) provides a mechanism that enables a horse to conserve energy on locomotion and respiration. The cascade of events can be described in 11 stages:

1. The forelegs become weight bearing and a momentary deceleration occurs
2. The force of gravity results in a downward movement of the head and neck
3. This stretches the elastic *ligamentum nuchae*.
4. The downward swing of the head/neck pendulum has a cantilever effect on the rest of the spine, the caudal end of which is raised.
5. Elevation of the hips tends to swing the hind legs forward, overcoming inertia and saving energy on locomotion (Rooney, 1998)
6. The deceleration and hip elevation results in the liver and abdominal contents being thrust against the diaphragm. The 'visceral piston' assists expiration
7. During the suspension phase of the stride, the elastic recoil of the ligamentum nuchae, now restores the head to its previous position.
8. Elevation of the head tugs on the non-elastic sheath of the brachiocephalic muscles.
9. This draws the forelegs forward, overcoming inertia and saving energy. The same foreleg response is seen in a standing horse that suddenly throws up its head, a movement that results in a forward displacement of one or both forelegs and, in extreme cases, rearing.
10. The combination of hind leg weight bearing and foreleg advancement elevates the rostral end of the spine.
11. The liver and abdominal contents now slide caudally, flattening the diaphragm and saving energy on inspiration.

Fig 12. Showing the normal and abnormal anatomical relationship of the esophagus and trachea. Tracheal deformations can take many different forms but a dorso-ventral flattening of the trachea, can result in the esophagus encroaching directly on the lumen of the trachea

Fig 13. A diagrammatic exposition of the reasons why the caudo-dorsal and bilaterally symmetrical distribution of the characteristic lesions of asphyxia-induced pulmonary edema (exercise-induced pulmonary hemorrhage) are compatible with upper airway obstruction as the cause, acting during the inspiratory phase of respiration. In this particular illustration, the obstruction is caused by atlanto-occipital flexion (jowl angle of 70°) for which the bit method of control is often responsible. But the same effect on the lungs is brought about by any upper airway obstruction. An etiological factor operating during inspiration at a point on the airway cranial to the bifurcation of the bronchi, satisfactorily explains the bilateral symmetry of

the pulmonary lesions. The caudal distribution of the lesions is also satisfactorily explained by an accepted principle of aerodynamics which states that suction pressure in a closed system increases with the distance from the point of the obstruction. This being so, it would be expected that barotrauma from abnormal negative pressure would be greatest at the caudal end of the lungs. Finally, the dorsal distribution of the lesions can be explained on the grounds that the elastic nature of the lung, suspended in the thorax from the spine, results in it acting like a slinky. Because of this, the dorsal air sacs tend to be more patent than the ventral and, therefore, more exposed to the damaging effect of an abnormal negative pressure on inspiration

Fig 14. Showing the pressure changes that might occur in the lung on inspiration, with and without obstruction of the upper airway. The diagrams explain the mechanism behind the hypothesis put forward in Fig 13 that asphyxia-induced pulmonary hemorrhage is caused by upper airway obstruction. The figures cited for transmural pressures are purely fictitious and are simply used to demonstrate the principle that is thought to be involved.

a). Upper airway unobstructed. In the absence of great resistance, the diaphragm draws air into the lungs easily and with minimal effort. The vacuum pressure in the air sac is normal (say -1) and so is the blood pressure in the capillaries (say +1). The differential or transmural pressure across the exquisitely thin membranes that comprise the air/blood barrier is, therefore, for the purpose of this example 2. This difference is not enough to suck fluid and red blood cells out of the pulmonary capillaries and into the interstitial tissue of the lungs or the air sacs and so normal gas exchange takes place.

b). Upper airway obstructed. Because of the high resistance to airflow, the diaphragm has had to work harder and make more effort to draw air into the lungs and the vacuum pressure in the air sac is now abnormal (say -3). Fluid and some red blood cells begins to be sucked from the capillaries into the interstitial tissues of the lungs (pulmonary edema) and this, in turn, causes the blood pressure to rise (say +3). The transmural pressure is now 6 and large enough to cause heavily blood-stained fluid to be sucked across the blood/air barrier from high to low pressure. Like the interstitial tissues, the air sacs also become edematous. Normal gas exchange is prevented. The horse becomes hypoxic and performance is reduced.

Fig 15. Showing the distribution of the trigeminal nerve (Cranial V). Bit-induced pain from the mental nerve in particular but also from the lingual, and buccal branches of the mandibular nerve and the palatine branch of the maxillary, is thought to be the source of trigeminal neuralgia and a major cause of headshaking. Pain is probably referred via the mandibular nerve to the trigeminal's two other major branches, the maxillary and ophthalmic nerves. This explanation is consistent with all the features of the headshaking syndrome in the horse.

Fig 16. Showing the basic design of the Acupressure Bitless Bridle. The diagram on the left is a ventral view of the head, illustrating the manner in which the reins cross over under the chin. Traction on one rein (open arrow) applies diffuse pressure on the opposite half of the head (solid arrows) and provides an inoffensive directional aid. Traction on both reins generates a benevolent squeeze of the whole of the head and triggers a 'submit' response at exercise (i.e., braking) similar in origin but different in manifestation from that which can be achieved in the resting horse by applying digital pressure to acupressure points behind the ear.