Painless amputation: history of a discovery that wasn’t made

Sam Shuster ponders on why his retrospective discovery of tourniquet anaesthesia wasn’t made earlier, when it would have mattered.

My realisation that using tourniquet ischaemia in the pre-anaesthetic era could have made amputation painless led to the idle thought of why it hadn’t been discovered, and then, to the even more idle thought of whether looking at why discoveries aren’t made would help us understand how they can be made. Because this could be answered only by a study of the history of amputation that looked for the ambience of ideas and practices rather than their chronology, that is where my idleness ended—with a new reading of the original documents on amputation procedures from the 16th century onwards, written by surgeons who had used or developed them, in addition to historical reviews.

The pain of pre-anaesthetic amputation

The horror of amputation without anaesthetic is revealed by contemporary accounts, of which this by James Cooke in 1685 is typical: “Dismembering is a dreadful operation; yet necessary, that the dead part may not injure the living, nor procure death... let one man be at the Patients back holding him, and another before him, holding the upper part of the limb; and a third holding that Part that must be taken off... see that your Instrument maker hath set the Teeth of your Saw wide enough, so it may not stick [have]... two saws, lest one should break” and several knives, because “after an operation or two [they] lose their keenness.” We should stop there, before the pain of cautery and sutures.

Many fainted during amputation, more remained agonisingly conscious, and a few suffered in silence (despite the more often quoted than referenced story of a sailor who sang Rule Britannia as his arm was removed). The brutality of amputation left a profound scar even on men as brave as Nelson: “The sufferings of the operation... strongly impressed on his mind... so painfully and deeply was the recollection engraven on his feelings.” He controlled his fear of further amputation by insisting that the pain had been from “coldness of the knife,” not its cut, and this allowed the comforting belief that the pain of the “next time” would be overcome by the warmed knives he demanded were always ready. Fortunately, Nelson’s concealment of his deep fear was never exposed.

The agony and sequelae of amputation were accepted because it was thought to be life saving and without alternative, “when part of a Limb is carried away, or the Bones so shattered... if that be left on, it will Gangrene, and Death will issue”; few people who refused surgery survived. The perceived necessity of amputation explains why so little was thought about its pain—some texts ignore it, others offer sympathy, but all early writings proposed speed as the only way to minimise pain. Yet, however fast the amputation, the devastating intensity of the agony remained.

So what else could have been offered? Volatile anaesthetics were not available before 1846, but alcohol and opium were; yet, amazingly, they were used postoperatively, if at all. In face of the “violent and inexpressible Pain... the Operator is to encourage the Patient, and having given him half a Glass of Wine to enable him the better to endure his Pain;” the preoperativegulp of alcohol was given for fortitude not anaesthesia. But was this what was commonly practised? One way of assessing best practice is to examine what was given to the best, as in Eshelby’s bald summary of his treatment of Lord Nelson: “The arm was immediately amputated and opium afterwards given.”

The reason that alcohol and opium “anaesthesia” was rarely used is not clear. Kirkup lists variable efficacy, dose, and nausea, but my reading of the original texts suggests another reason—surgeons believed patients had to be conscious and alert to withstand amputation: “proceed as soon as possible... otherwise the patient may... be so exhausted to make it very hazardous, and his recovery doubtful.” This belief probably explains the extraordinary sitting posture used. The notion that its purpose was to achieve pain relief by inducing syncpe is unlikely, because fainting was considered an undesirable response. Although the association of “alertness” with response was correct, cause and effect were confused, and this led to the unfortunate exclusion of alcohol and opium preoperatively.
Finally, physicians were licensed to use drugs but surgeons just operated—this may have contributed to the poor appreciation of the use of drugs and non-surgical methods, and may partly explain why use of the tourniquet wasn’t extended beyond haemostasis.

**Tourniquet anaesthesia and painless amputation**

The tourniquet evolved from the bandage, thread, and screw device; it allowed vessel ligation and banished painful cautery. It was applied immediately before surgery; had it been applied earlier, anaesthesia would have allowed pain-free amputation. Impaired neural function from ischaemia—as when a leg “goes to sleep”—is so familiar that it tends not to be noticed. I was reminded of it when using a sphygmomanometer just above arterial pressure to stop the circulation and fix vasoactive agents in the forearm, as with histamine. Limb ischaemia induced a proximally spreading anaesthesia with motor paralysis, complete in 30 minutes, that recovered rapidly on release. But a narrow cuff and higher pressures cause local pain and nerve damage from compression. Thus, application of a broad low pressure tourniquet 30 minutes before surgery would have allowed painless amputation in the pre-anaesthetic past. Tourniquet anaesthesia could still be used in extreme circumstances; it probably has been used unknowingly in the self amputation of trapped limbs, with the entrapment acting as a tourniquet.

**Why wasn’t tourniquet anaesthesia discovered earlier?**

I made my anachronistic discovery when studies of naval health revived my earlier tourniquet observations, and its ease of discovery made me question why it had not been made before anaesthesia made it irrelevant. Absence of the idea of improving pain control and, therefore, methods for its achievement, and the isolation of surgeons as technical practitioners are obvious, but re-examination of the historical accounts revealed a more interesting explanation.

When any procedure is used, all possible variants will occur, most of which inevitably follow the law of Murphy’s cynical partner; thus although the tourniquet was applied immediately before amputation, there will have been exceptions; indeed the gansorous consequence of leaving a tourniquet too long were well known, as with tight splinting. Although the opportunity to see the progressive course of tourniquet anaesthesia must have occurred, I found no records of such observations in the original texts or recent reviews.

In addition to this tantalising closeness of the observational opportunity, I also found ideas that could have led to tourniquet anaesthesia. In 1637, William Clowes notes, “the pain of the [haemostatic] binding doth greatly obscure the knife and feeling of the incision.” James Yonge’s 1679 account says, “nor shall the pain of that operation be comparable to what it would be, were not the member nummed by the Compress.” Of course, this was distraction by tourniquet pain—the onset was too rapid for tourniquet anaesthesia. Nevertheless, the idea of “numbing” wasn’t that far off, and it got closer when the anaesthetic effect of screw pressure on a nerve was found. So the ideas and techniques were there, waiting for the link; why didn’t it happen?

Although accidental tourniquet anaesthesia must have occurred, either it wasn’t noticed or its application wasn’t realised. Failure to notice is a consequence of the need for reflex action rather than thought, when quick responses are essential. If it had been noticed, even in part as some accounts suggest, surgeons of the time were essentially operative technicians, working at great speed and stress at times of battle, with no time to consider, analyse, and classify the “interesting” neural consequences of tourniquet ischaemia, let alone develop its possible uses, as would a clinical researcher whose main life stress is finding a grant.

Thus, the failure of busy surgeons to extend their use of the tourniquet to anaesthesia is an almost inevitable consequence of the constraints of practice at the time. Having reached the limits of speed for reducing pain, further improvement needed awareness of the problem and a search for its solution; and that could only come with independence from clinical constraints. Time for reflection and experiment is essential to clinical advance and underlines the differences in the methods and traditions of clinical practice and clinical research. The gap between the two has closed, but, sadly, it is still obvious—otherwise, the retrospective discovery of tourniquet anaesthesia would have been made sooner, when it mattered.

Sam Shuster emeritus professor of dermatology, University of Newcastle upon Tyne; Newcastle upon Tyne NE2 4HH sam@shuster.eclipse.co.uk

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**Image:** Images from Charles Bell: Illustrations of the Great Operations of Surgery

**Figure:** Tourniquet anaesthesia and painless amputation