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Does bipolar electrocoagulation time affect vessel weld strength?

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Abstract

The value of the bipolar electrocoagulator in the haemostasis of bleeding ulcers is controversial. We have therefore investigated the effect of different coagulation times on vessel weld strength achieved by the bipolar device. Welds were then made in vessels of known diameter using a standard 10F endoscopic haemostatic probe at coagulation times of two and 20 seconds. The intravascular temperature achieved at each time was measured. Vessel weld strength achieved by bipolar electrocoagulation was much greater at 20 seconds (approximately twice that at two seconds) and was highly significantly greater at all vessel diameters. There was a gradual reduction in weld strength with increasing vessel diameter, an effect that was seen for both two and 20 seconds of electrocoagulation. Intravascular temperature was significantly higher at 20 seconds than at two seconds. We conclude that vessel weld strength is related to coagulation time and that any future studies comparing the bipolar electrocoagulator with other haemostatic devices should use longer periods of bipolar electrocoagulation and record the coagulation time in order to optimise the clinical value of the device.

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The Circon-ACMI BICAP multipolar endoscopic diathermy probe is widely used to control upper gastrointestinal bleeding and is much less expensive both to purchase and maintain than a laser. Its ceramic probe tip has three longitudinal gold electrodes of alternate polarity which are carried around to the end of the probe, allowing end or side application. There is a central wash channel which is useful in achieving and maintaining good visualisation of the bleeding ulcer or lesion.

The bipolar electrocoagulator (BICAP, ACMI, Stamford, CT, USA) has been shown to be of value in the haemostasis of bleeding ulcers.[1,2] Other studies, however, have failed to show benefit, and it has been suggested that the thoroughness of the coagulation may be an important factor in explaining these differences.[3-5]

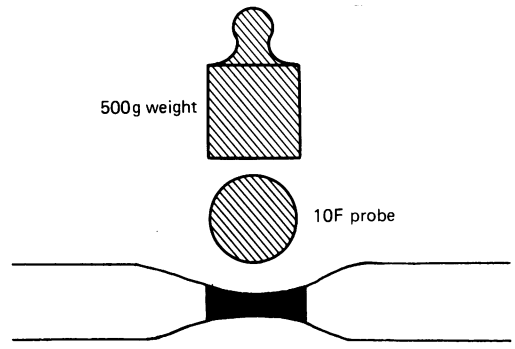

Figure 1: Cross-section of vessel and probe during coagulation.

We therefore investigated the effect of different coagulation times on vessel weld strength achieved by the bipolar device. The intravascular temperatures achieved at short and long periods of coagulation were also measured.

Method

Six New Zealand white rabbits were anaesthetised (thiopentone induction, halothane maintenance). The main vessels from the infradiaphragmatic aorta to the external iliac arteries were dissected out and excised.

The excised vessel was then cannulated at its proximal end with an 18F Venflon. The vessel was then water perfused with the distal end occluded to allow small branches to be clipped and ligated. In this way the vessel was rendered sufficiently watertight to allow increases in pressure without loss due to leakage.

The diameter of the cut end of the vessel was measured in each case and analysis was performed in three arbitrarily defined size categories: 0·5–1·9 mm vessels, 2–3·9 mm vessels, and 4–6 mm vessels.

A weld was then made in the vessels using a standard 10F endoscopic haemostatic probe (BICAP II). The weld was made with the side of the probe completely across the vessel so that it was at right angles to the vessel, using a 500 g weight placed on top of the probe in each case to standardise experimental conditions (Fig 1). Saline was used in each experiment to keep the vessel moist.

The vessels were randomly assigned to receive either two or 20 seconds of coagulation from a standard BICAP II bipolar electrocoagulation device at power setting 7 (approximately equal to a power output of 40 W).

A short 'T' piece was inserted into the system close to the cannula to measure the pressure. This was done with a Sensym type SPX.N series

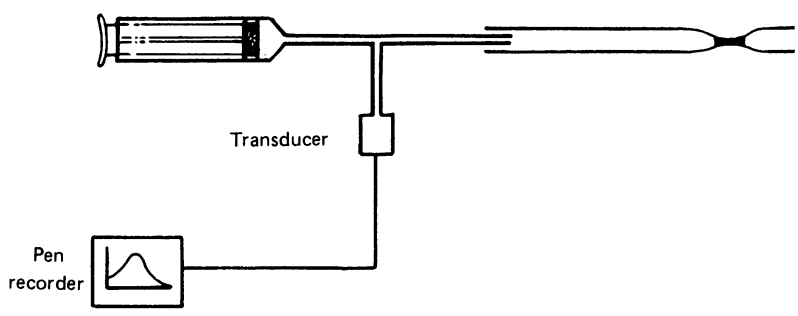

Figure 2: Experimental preparation to measure vessel weld strength.

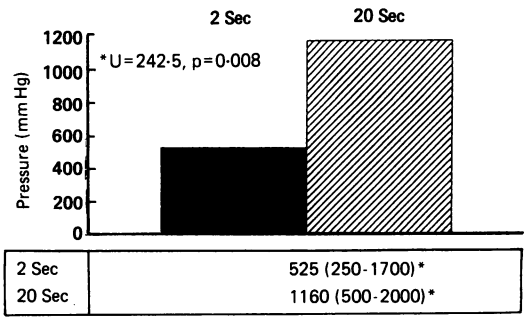

Figure 3: Median vessel weld strength of 0·5–1·9 mm vessels at two and 20 seconds of coagulation.

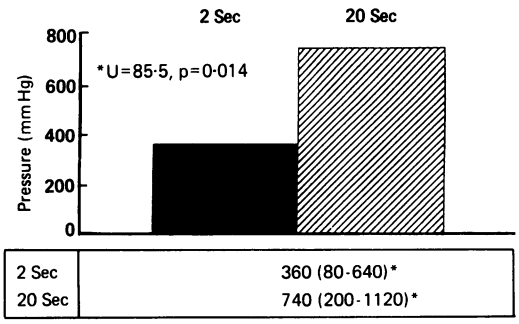

Figure 5: Median vessel weld strength of 4–6 mm vessels at two and 20 seconds of coagulation.

transducer attached to a pen recorder which had previously been calibrated with an aneroid manometer (Fig 2).

A steady increase in pressure from a 50 ml syringe of water was applied until the weld in the vessel fractured, at which point the pressure (the vessel weld bursting strength) was noted.

The intravascular temperature achieved at each of the time periods was also measured using a hypodermic type stainless steel thermocouple probe. The experiment was repeated 10 times at each of the time periods.

STATISTICS

The data obtained from the experiments were not normally distributed, so the median and range are quoted for the vessel weld strength at each of the time periods (two and 20 seconds) and for the three vessel size groups. Statistical comparisons are made between the weld strength achieved at two and 20 seconds, coagulation using the Mann-Whitney U test.

Results

The vessel weld strength achieved by bipolar electrocoagulation was much greater at 20 seconds than at two seconds. Figures 3 to 5 show the median weld strength after two and 20 seconds for all three categories of vessel diameter; the range of weld strengths at the two time intervals and the significance values are also given. Vessel weld strength at 20 seconds was approximately twice that at two seconds, and was highly significantly greater at all vessel diameters.

There was a gradual reduction in weld strength with increasing vessel diameter. This effect was seen for both two and 20 seconds of electrocoagulation (Table I).

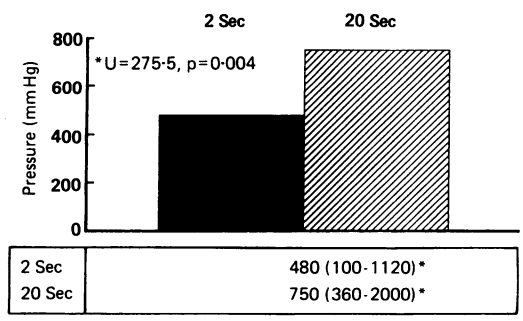

Figure 4: Median vessel weld strength of 2–3·9 mm vessels at two and 20 seconds of coagulation.

The intravascular temperature was significantly higher at 20 seconds compared with two seconds (Fig 6).

Discussion

Endoscopic control of bleeding peptic ulcer is an important modern treatment method.[6] BICAP electrocoagulation has been used in several clinical trials with a variety of results. Although the trials have been partially confounded by problems with trial size (and accompanying type II error), differences in probe diameter, endoscopic experience, differing BICAP power output etc, some have been remarkably successful, while others clearly have not.

Some randomised studies of bipolar electrocoagulation *versus* sham treatment have shown a significant reduction in the rebleeding rate among treated patients, while others have failed to show any difference (Table II).

The role of technical factors that may cause these differences has not been investigated, and in this study we have considered the most basic of these – coagulation time.

In a recent study the heater probe was shown to produce a greater bond strength than the BICAP probe, however, a coagulation time of only two seconds was used for the BICAP compared with 20 seconds for the heater probe.[7]

Vessel weld strength for vessels 0·5–1·9 mm in diameter was more than doubled to a median of 1160 mmHg. Similar increases were seen for larger diameter arteries. The diameter of vessel most similar to that in the exposed vessel in a patient with a 'high risk' bleeding ulcer is in this group of vessels (the mean diameter of eroded arteries in resected stomachs is 0·6 mm).[8]

The relation between vessel weld strength and systolic blood pressure with regard to the haemostasis of bleeding ulcers is unknown, but it is felt that any technique that causes a higher vessel weld strength is preferable to one producing a low weld strength. It is also of note that our high weld strengths were achieved under ideal conditions on the bench, with perfect apposition of

TABLE I *Vessel weld strength compared with vessel diameter at two and 20 seconds of electrocoagulation*

	Median weld strength (mmHg)	
Vessel diameter (mm)	*2 secs*	*20 secs*
0·5–1·9	525	1160
2–3·9	480	750
4–6	360	740

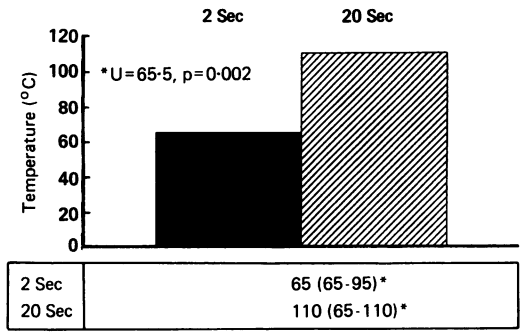

Figure 6: Median intravascular temperature at two and 20 seconds of coagulation in 4–6 mm vessels.

probe and vessel at 90°, a situation not usually found in practice. It may well be that longer coagulation times are required to produce an adequate temperature to weld the vessel satisfactorily.

Our study indicates that vessel weld strength does depend on BICAP coagulation time. The median vessel weld strength achieved using the BICAP probe for 20 seconds in the 0·5–1·9 mm vessels (1160 (500–2000) mmHg) was comparable with that achieved in 1 mm vessels using 120 and 240 joules of heater probe energy: mean (SD) 1336 (238) mmHg and 1456 (118) mmHg respectively.

It is interesting to note that the weld strength achieved by Johnson *et al* after two seconds of BICAP coagulation on 1 mm vessels (mean (SD) 765 (418) mmHg)[7] was similar to our result of 525 (250–1700) mmHg.

The variation in the results of previous clinical trials using BICAP may be explained by the finding in our experiments that the vessel weld strength was very clearly related to coagulation time.

TABLE II *Results of randomised trials of BICAP compared with untreated controls*

Author	Probe type	No of patients	% Rebled	
			Control	BICAP
Goudie *et al*[5]	7F	46	20	33
Kernohan *et al*[3]	7F	45	29	43
O'Brien *et al*[2]	7F	204	33	17*
Brearley *et al*[4]	NS	44	38	30
Laine *et al*[1]	10F	44	57	14**

*p=0·01; **p=0·0001; NS=not stated.

Any future studies comparing the bipolar electrocoagulator with other haemostatic devices should use prolonged periods of bipolar electrocoagulation and record the coagulation time in order to optimise the clinical value of the bipolar device.

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