The Shaw Haemostatic Scalpel in Paediatric Surgery: Clinical Report on 3000 Operations

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Summary

This report presents the experience in a prospective series of 100 operative procedures in all fields of paediatric surgery with the Shaw haemostatic scalpel, which we have subsequently used in more than 3000 further operations. The Shaw scalpel proved to be advantageous in about 80% of major cases. The scalpel cuts tissue with a sharp steel edge, like a cold scalpel, and simultaneously seals blood vessels by heat thermally conducted to the tissue from heated blade which is electrically insulated from the patient. The heat seals most small blood vessels (under 2 mm) as they are cut. Since no electric current passes through the patient, a grounding pad is not needed and the risk of accidental electrical current burns at grounding sites is eliminated. Muscle stimulation associated with the use of a normal cautery is avoided, improving surgical precision of cutting. The Shaw haemostatic scalpel minimizes damage to the tissue as compared with other thermocoagulating instruments. Since it seals small vessels as it cuts tissue, it largely eliminates the flow of blood into the incised area and allows better visibility of the surgical field. The use of the scalpel requires a different cutting technique which is however easy to learn. The Shaw haemostatic scalpel reduces blood loss and overall operating time in major cases. It is relatively inexpensive and can be recommended for use in paediatric surgery.

Zusammenfassung

Es wird über Erfahrungen bei 100 kinderchirurgischen Operationen auf nahezu allen Gebieten der Kinderchirurgie mit dem Shaw Hemostatic Scalpel berichtet; nach dieser ersten Versuchsserie haben die Autoren das Instrument bis heute in mehr als 3000 weiteren Operationen verwendet. Das Shaw Hemostatic Scalpel erwies sich als günstig in mehr als 80% der größeren Eingriffe. Es schneidet das Gewebe mit einer scharfen Stahlklinge wie ein normales Skalpell und versiegelt gleichzeitig die Blutgefäße durch Hitzekoagulation. Die Klinge wird auf einer gewünschten Temperatur zwischen 110 und 260°C konstant gehalten. Die drei in der Klinge enthaltenen elektrisch geregelten Temperaturelemente sind vom Patienten isoliert. Blutgefäße von 2 mm Durchmesser und weniger werden während des Schneidens verschlossen. Da kein elektrischer Strom durch den Patienten geht, ist eine Erdung nicht nötig, und das Risiko elektrischer Verbrennungen ist ausgeschlossen. Dies ist in Anbetracht der zahlreichen modernen Überwachungsgeräte, die diese Gefahr vergrößern, von besonders großer Bedeutung. Auch kommt es nicht zu Muskelzuckungen, die sich beim Schneiden mit dem üblichen elektrischen Messer ergeben. Das Shaw Hemostatic Scalpel setzt einen geringeren Gewebeschaden als das handelsübliche elektrische Messer. Da die Gefäße bei der Gewebedurchtrennung verschlossen werden, wird das Einströmen von Blut in das Operationsfeld weitgehend vermieden. Dies erlaubt eine "bloodless surgery" mit entsprechend besserer Detailsicht im Operationsfeld. Der Gebrauch dieses Messers erfordert eine etwas andere Schnittechnik, die jedoch leicht zu erlernen ist. Das Shaw Hemostatic Scalpel reduziert den Blutverlust und die Operationszeit bei größeren chirurgischen Eingriffen. Es ist relativ preisgünstig und kann für den Gebrauch in der Kinderchirurgie empfohlen werden.

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Résumé

Nous rapportons 100 observations de chirurgie infantile pratiquée avec le bistouri hémostatique de Robert Shaw. Par la suite, nous avons pratiqué 3000 autres interventions par cette méthode. Ce système de bistouri hémostatique fut particulièrement bien adapté dans 80% des interventions. La section pratiquée est aussi fine que celle d'un scalpel usuel et s'assortit d'une hémostase immédiate par coagulation. La lame doit être maintenue à une température oscillant entre 110 et 260°C. Les éléments chauffants électriques de la lame sont bien évidemment isolés du patient. Pour les vaisseaux sanguins d'un diamètre égal ou inférieur à 2 mm, une hémostase spontanée a lieu pendant la section même. Une prise de terre n'est pas nécessaire et tout risque de brûlure est écarté du fait qu'aucun courant électrique ne traverse le patient. Ceci est primordial, étant donné la multiplication des appareils de surveillance électriques.

Autre avantage: l'absence de conduction électrique à travers le patient évite toute contraction musculaire, chose que l'on trouve à l'utilisation du bistouri électrique habituel. Les lésions du bistouri Shaw sont moindres que celles provoquées par les bistouris électriques habituels. Cette hémostase spontanée permet d'éviter une déperdition sanguine per-opératoire. De plus, la sécheresse de la plaie permet une meilleure vision du champ opératoire. Si l'utilisation de ce bistouri nécessite une nouvelle technique, celle-ci est particulièrement simple à acquérir.

Cet instrument permet à la fois une réduction des pertes sanguines et du temps opératoire au cours de la chirurgie lourde. Autre avantage: son prix modique.

Introduction

Haemostasis is an important and frequently time-consuming part of surgery. Precise control of bleeding during operative procedures is an essential tool, especially in the paediatric age group. This is a report on our experience with the Shaw haemostatic scalpel in 3000 operations at our paediatric surgical centre. We started testing this system in a prospective series of 100 cases in 1982. By 1987, about 100 surgeons were on the users reference list for the Shaw scalpel in the United States. There are some reports on the successful use of this scalpel in animal experimental surgery and some favourable reports in different fields of surgery in humans [1–10]. However, the Shaw haemostatic scalpel is not well known amongst paediatric surgeons, especially in Europe and there are no reports on its regular use in this field so far. Our positive experience justifies this report.

Description of the System

The haemostatic scalpel or "hot knife" was invented by Robert Shaw, M.D., a cardiovascular surgeon, and is manufactured by Oximetrix Incorporated Mountain View, California, United States (Fig. 1). The Shaw scalpel system consists of three components: an electronic controller instrument; a reusable scalpel handle connected to the controller by a lightweight, flexible electrical cable; and sterile disposable scalpel blades. The controller unit operates on the standard hospital power supply (115 or 120 V, 50–60 Hz) to provide a pulsed direct current used to heat the scalpel to a selected temperature in the range 110°–260°C. The controller provides an audible tone and visual display to show system operating status and

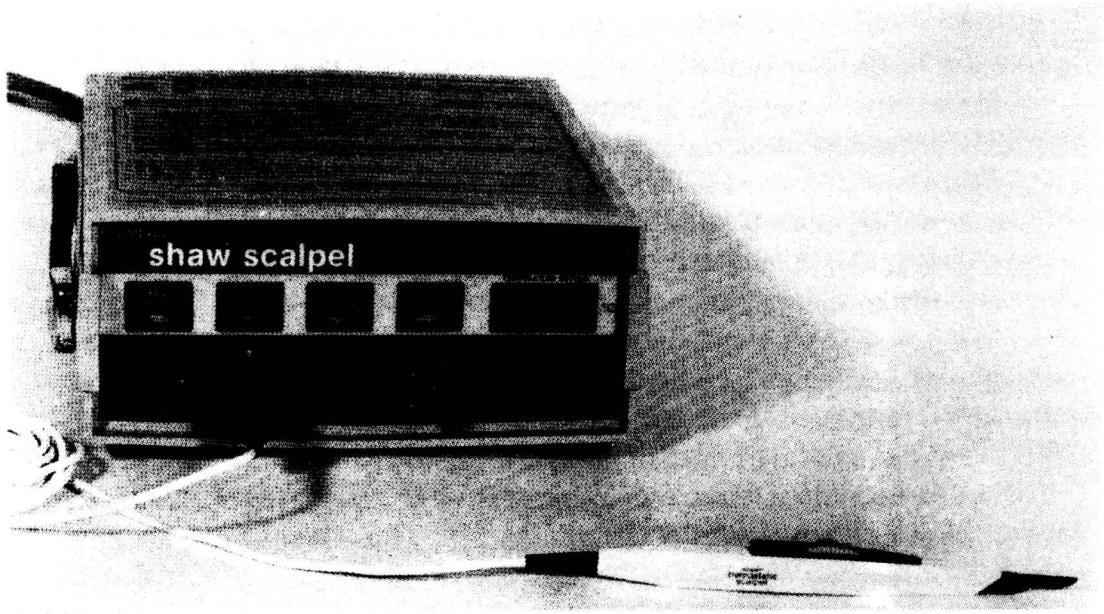

Fig. 1. The Shaw haemostatic scalpel. The controller unit and the handle with the blade

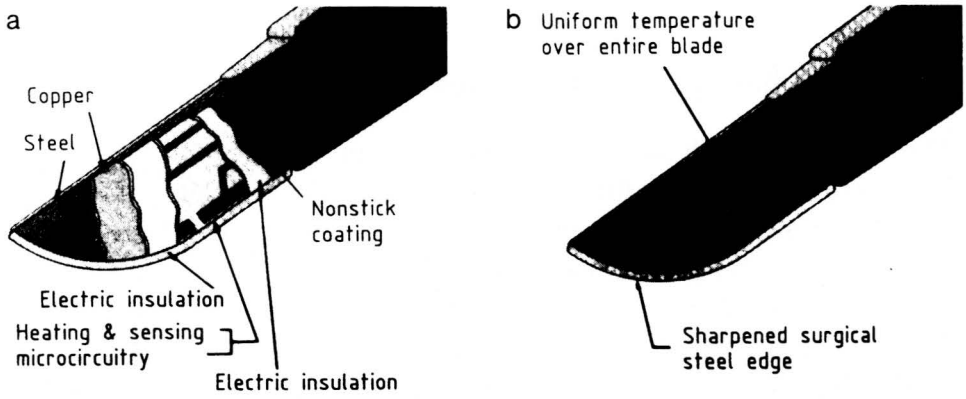

Fig. 2a, b. The Shaw haemostatic blade. **a** "Structure" (see text), **b** Teflon coating

blade temperature setting. The controller senses and powers microelectronic circuitry in the scalpel blade to maintain the blade at the desired temperature within extremely narrow limits. This permits the surgeon to maintain careful control over the degree of thermal injury produced in the tissue. The temperature can be controlled and raised in 10° increments by a small button enclosed in the scalpel handle. When the blade is turned on, it reaches the desired temperature within 3–4 s and when it is turned off, it cools very rapidly. The Shaw blades are individually packed, sterile and ready for use. They are similar in size and shape to conventional scalpel blades (No. 10 and 15) and have the same sharp surgical steel cutting edges to retain the precision and feel of the cold scalpel when cutting. They are constructed from surgical steel and coated with copper and a Teflon (PTEE) outer coating, except for the cutting edge (Fig. 2a, b). The Teflon coating is important since coagulated blood tends to collect on the scalpel. With the Teflon coating, the blade can be easily cleaned by gentle wiping on a sterile gauze.

The blades contain three individual heating and sensing units along the belly and cutting tip of each blade. The microcircuitry incorporated within the Shaw blade itself maintains the cutting edge temperature within the necessary limits, selectively delivering additional thermal energy only to those regions of the blade losing heat by tissue contact. This allows one to compensate for the varying heat losses that occur during surgery and to maintain the cutting edge in the desired temperature range. The disposable blades are discarded when they become dull, just like conventional scalpel blades. The reusable scalpel handle and the cable to the controlling unit can be gas sterilized. The manufacturer provides a trained representative who can give technical instruction on the design and proper use of the instrument. The cost of the complete Shaw haemostatic scalpel is approximately 3000 # and the blades are approximately $ 6 each.

The Shaw scalpel system conducts heat from its sharp, heated blade to a thin layer of tissue adjacent to the cutting edge. The heat seals most small blood vessels (below 2 mm) as they are cut, largely eliminating the flow of blood into the incised area. Since the blade is electrically insulated from the patient, and no electric current passes through the patient, no grounding pad is needed. Muscle stimulation associated with passing electric current through the body is also eliminated.

The First Pilot Study of 100 Cases

The theoretical advantages prompted us in 1982 to test the value of the Shaw haemostatic scalpel in different fields of paediatric surgery in a prospective series of 100 operations. With a few exceptions, all procedures have been carried out by the author. Every patient had a special questionnaire noting temperatures used at different steps of operation, number and quality of blades used during the procedure, a comparison of the haemostatic scalpel with the cold scalpel and electrosurgical units with respect to the amount of time required, the estimated tissue damage, visibility of the operating field and the quantity of fluid administered to the patient. The patients were carefully followed postoperatively for any complications, especially wound healing, infections and cosmetic appearance of the scar at late follow-up.

Results

A total of 90 children with an age range from 1 day to 15 years underwent altogether 100 different procedures which are listed in Table 1.

General Evaluation and Technical Considerations

The effective use of the thermally regulated haemostatic scalpel required development of a different technique from the one we were using before. Surgeons are usually accustomed to cut tissues rapidly and then return to the same area to coagulate bleeding vessels which have been cut. With the Shaw haemostatic scal-

Table 1. Shaw haemostatic scalpel in paediatric surgery: diagnoses in the first 100 pilot cases

Neonatal surgery	
Intestinal malrotation, duodenal atresia, etc.	3
Enterostomy (NEC)	6
Sacroperineal pull-through in anorectal atresia	4
Gastrostomy	4
Abdominal and general surgery	
Hepatoportoenterostomy (Kimura-Kasai)	2
Splenectomy	2
Hemisplenectomy	2
Excision of mesenteric lymph node	4
Appendectomy	5
Inguinal hernia	6
Cryptorchidism	6
Urology	
Cohen's procedure in vesicoureteral reflux	12
Bladder reconstruction in bladder exstrophy	3
Excision of bladder diverticulum	1
Excision of bladder (after bladder exstrophy)	1
Cutaneous ureterostomy	3
Nephrectomy	1
Heminephrectomy	3
Bone surgery	
Juvenile bone cyst near humerus	2
Autologous spongiosaplasty (pelvis)	4
Osteotomy of pelvis (bladder exstrophy)	3
Biopsy of bone tumour (Ewing's sarcoma, osteosarcoma)	3
Neurosurgery	
Myelomeningocele	5
Hydrocephalus, Spitz-Holter shunt	3
Epidural haematoma	2
Insertion of Richmond screw	2
Tumour surgery	
Wilms' tumour	2
Resection of soft tissue tumour	2
Tumour biopsy	4

pel the blade and its thermal energy have to be used in such a manner that bleeding does not begin. This is done by making incisions at a somewhat slower cutting speed than with the cold scalpel or the Bovie scalpel. The incisions have to be done at a constant speed through thinner layers of tissue to maintain constant and meticulous haemostasis at every step. The cutting technique required for effective use of the Shaw scalpel was initially unfamiliar and the use of the instrument was therefore fully effective only after a short learning period. However, this change in technique was not difficult to achieve and much easier than that required for lasers. The time loss because of the lower cutting speed was more than compensated by the gain in time due to a dry operating field. For skin incisions, we usually used a temperature of 110°C. After cutting through the dermis, the blade

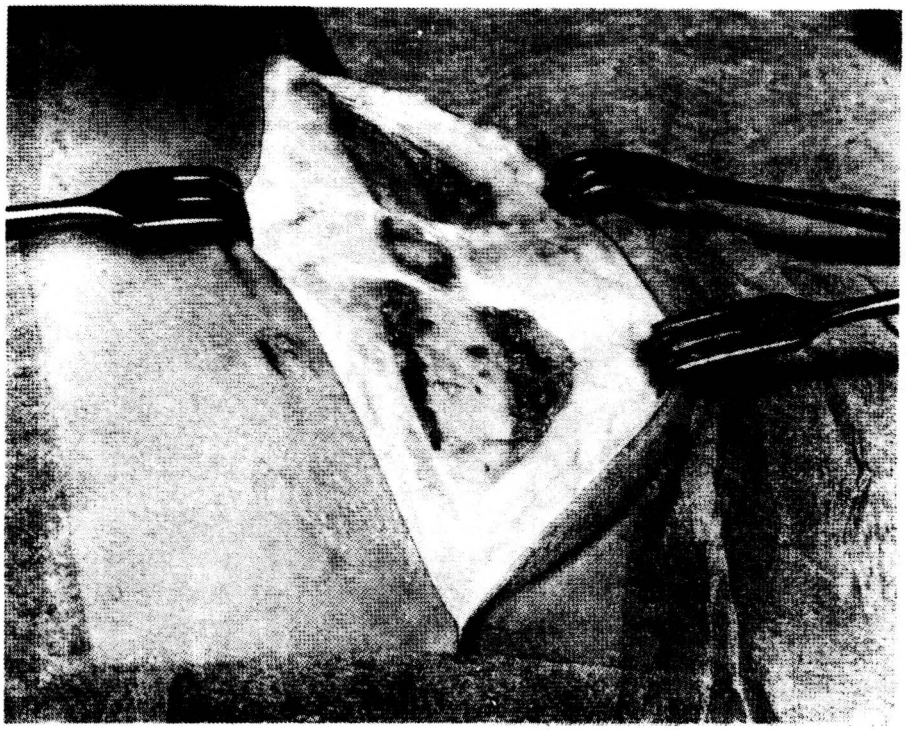

Fig. 3. Abdominal incision with the Shaw haemostatic scalpel; bloodless surgery

temperature was usually raised to 220°–260°C. The grade of haemostasis with these temperatures was usually excellent in subcutaneous and fibrous tissues and muscles. Of course, one has to adapt the speed carefully to the type and vascularity of the tissues at these high temperatures. However, with increasing experience this was not very difficult. The haemostasis achieved was usually excellent, especially in abdominal and thoracic wall incisions and after a short learning period, no additional electrosurgical unit (ESU) was used and only a few or no ligatures at all were necessary. Figure 3 shows a bloodless field in a patient with an upper abdominal transverse incision. The dry operating field gave much better visibility and was of considerable advantage to the surgeon.

Cutting through muscles could be done with more surgical precision because muscle stimulation associated with passing electric current through the body is eliminated. Since no electric current passes through the patient no grounding pad is necessary and the risk of accidental electrical burns at grounding sites is eliminated. This was of special interest for us in neonates and infants. Deep in the abdominal cavity, there was sometimes a slight mechanical inconvenience because of the cable on the proximal end of the scalpel handle. It is important to realize that if the ESU is used in conjunction with the Shaw scalpel, care must be taken not to touch the blade with the activated ESU as this would result in internal damage to the electronics in the Shaw controller unit. In minor procedures, usually one No. 10 or No. 15 blade was used, in major procedures two to four blades were necessary. The blades were mostly as sharp as normal cold steel blades and maintained their sharpness for about 20 min. However, there were a few blades which seemed to get dull more quickly and a few which seemed not to be as sharp as nor-

mal cold blades initially. A few trials to resterilize the blades were unsuccessful because they got dull. We initially thought that the Shaw haemostatic scalpel would also be advantageous in surgery on the liver and spleen. However, we were not very successful with this system on these parenchymatous organs because of too much coagulated blood on the blades, in spite of the Teflon coating.

Altogether, the Shaw haemostatic scalpel proved to be useful in about four-fifths of our operations. The immediate haemostasis, allowing for increased visibility in the operative field, and the lack of muscle stimulation, allowing more precise cutting, was a considerable advantage in all major operations and was of course of special interest in neonatal surgery. In this field, perfect haemostasis and excellent visibility of the operative field is especially important. We also had the impression that, in comparison with conventional ESU, there was less tissue damage with the haemostatic scalpel. In contradiction to reports on adults, we have the impression that the quantity of fluid administered was not greatly influenced by the use of the Shaw scalpel, mainly because meticulous operative haemostasis is mandatory in paediatric surgery anyway. However, haemostasis was much more easy to achieve and in some extensive procedures we also think that the quantity of blood administered was reduced. In very major procedures, the operative time seemed to be reduced; in none of the procedures was it longer than with conventional techniques.

Wound Healing

There was one infection of an abdominal wall incision with partial disruption of the wound on day 14 in an infant with hepatoportoenterostomy (Kimura–Kasai procedure) because of biliary atresia. One patient had a slight seroma which healed without sequelae, in three patients the incision was red from day 2 to day 4 which could be explained by too low a speed of skin or subcutaneous tissue incision, resulting in slight thermal injury. However, wound healing was subsequently normal in these patients. All other patients had completely uneventful postoperative courses, normal wound healing and the cosmetic appearance of the scar at late follow-up was good and equivalent to incisions with the cold scalpel. The complication rate of wound healing was similar to the complication rate with the cold steel scalpel.

Discussion

Our first series of 100 operations with the Shaw haemostatic scalpel convinced us of the advantages of this new technique and the Shaw scalpel is now successfully used by all senior members of our staff. Controlled experimental animal studies were conducted during 1978 and 1979 by Stanley M. Levenson, Professor of Surgery, Albert Einstein College of Medicine, New York, a recognized authority on wound healing [3]. Levenson compared postoperative wound breaking strength in standard paramedian incisions in rats. The incisions were made with an ordinary scalpel, the heated Shaw haemostatic scalpel and the conventional ESU unit, with

both coagulation and cutting. Wound healing and breaking strength were tested between 7 and 42 days postoperatively. They were proved to be highest in incisions made with the conventional scalpel and the thermally regulated Shaw haemostatic scalpel. At day 21 there was a slight difference in favour of the conventional scalpel which was, however, not demonstrable later on. Both the conventional scalpel and the Shaw scalpel produced less tissue damage than incisions made with the ESU and there was no instance of wound infection in any of the rats of the whole series. The conventional scalpel and the Shaw scalpel produced statistically stronger wounds than incisions made with the ESU in either its coagulation or cutting mode. Wound resistance to infection after incisions with the Shaw scalpel and the conventional scalpel by purposely inoculated skin incisions in rats up to 10^8 *Pseudomonas aeruginosa* or *Staphylococcus aureus* did not show any difference between the conventional scalpel and the Shaw scalpel at various temperatures. No wound infection developed in either group.

Levenson also compared the cold scalpel and the thermally regulated haemostatic scalpel for excision of third-degree burns in Hampshire–Landrace pigs [4]. He found that the blood loss was significantly less than in comparable excisions carried out with the usual "cold" surgical scalpel and the "takes" of immediately applied skin grafts were similar following excision with the cold surgical scalpel. He was then the first to apply the Shaw haemostatic scalpel successfully in a 50-year-old man with 35% third-degree burns [4]. Since then, favourable reports have been published by different authors from many fields of surgery [1, 2, 5–10]. Salyer [7] reported on its use in plastic and reconstructive surgery, especially in craniomaxillofacial surgery and cleft palate surgery. Pilnik and co-workers [6] reported on the use of the haemostatic scalpel in operations on the breast, pointing out especially the reduction of blood loss. None of their 155 mastectomies done with the heated scalpel required a single blood transfusion. Fee [2] reported on 25 patients who underwent parotid gland surgery with the Shaw scalpel and compared this group of patients with another group of 25 patients who had similar surgery by conventional techniques. Overall, the patients operated on with the Shaw scalpel had less blood loss and shorter operative times. In addition, in patients who underwent superficial parotidectomy, the incidence of temporary partial facial nerve paralysis was lower with the Shaw scalpel. They concluded that the Shaw haemostatic scalpel was a safe efficacious instrument for use in parotid gland surgery. These authors especially stress the better visibility due to the dry operative field. Fee [1] also reported on the use of the Shaw scalpel in head and neck surgery and classified the procedures in 50 patients on a scoring system for effectiveness of haemostasis. Subjective equipment evaluation resulted in a mean score of 3.8 (1 = worthless, 5 = excellent). Overall, the Shaw system was a worthwhile surgical tool in over 70% of cases. The author stresses that the Shaw scalpel system is especially excellent for raising flaps and for use in precise surgery where small capillary bleeding typically obscures visibility, especially in parotid surgery.

Moazed and co-workers [5] reported on the use of the Shaw haemostatic scalpel in ophthalmic surgery. They also stress the preservation of a good view of the anatomy during dissection and come to the conclusion that the Shaw scalpel

simplifies operative procedures at the orbit and the lid. They also noted a significant shortening of surgical procedures in their ten cases. Tromovitch and co-workers [10] used the Shaw haemostatic scalpel in 150 minor and major dermatological procedures. They state that "the dissection and control of bleeding was infinitely easier" with the Shaw scalpel and that "this electric scalpel will surely become a favourite instrument for dermatological surgeons". Takagi and co-workers [9] used the Shaw haemostatic scalpel in 7 radical operations for oral cancer and compared the amount of bleeding and postoperative exudate and the occurrence of postoperative complications with that from 12 operations performed with the conventional steel scalpel. The blood loss during the radical neck dissection procedure performed with the Shaw scalpel was 39% of the control value, and no blood transfusions were necessary.

We add our own experience with over 3000 cases with the Shaw haemostatic scalpel to these favourable reports in the literature. We would like to stress again the advantages which are especially important in paediatric surgery. The Shaw scalpel allows one to seal small vessels with heat as it cuts, largely eliminating the flow of blood into the incised area and giving an improved visibility and a dry operative field. Since no electric current travels through the patient, there is no disturbing excitation of muscles, allowing for more precise cutting. There is also no earthing pad required which eliminates the potential danger of electrical burns. Improved visibility, reduced tissue damage, lack of muscle stimulation and the elimination of possible electrical burns are of special interest for the paediatric surgeon. After a short training in cutting techniques, the use of the Shaw haemostatic scalpel, facilitate greatly haemostasis, another important factor in young patients.

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