THE A-V IMPULSE SYSTEM REDUCES
DEEP-VEIN THROMBOSIS AND SWELLING AFTER
HEMIARTHROPLASTY FOR HIP FRACTURE

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We performed a prospective randomised controlled trial of the A-V Impulse System in 82 patients treated by hemiarthroplasty for subcapital fracture of the femoral neck.

The incidence of proximal deep-vein thrombosis as assessed by Doppler ultrasonography was 23% in the control group and 0% in those using the device (p < 0.01). Calf and thigh circumferences were measured in both groups at seven to ten days after operation. In the treatment group there was a mean relative reduction of postoperative swelling of the thigh by 3.27 cm (p < 0.001) and of the calf by 1.55 cm (p < 0.001).

The A-V Impulse System appears to be a safe and effective method of reducing the incidence of proximal deep-vein thrombosis, and of postoperative swelling.

It is well recognised that patients undergoing surgery for fracture of the neck of the femur are at high risk of developing deep-vein thrombosis (Hull and Raskob 1986). Without prophylaxis more than 20% develop proximal thrombosis, with a total incidence of thrombosis of 40% to 70% (Haake and Berkman 1989), and 7% to 10% may die from pulmonary embolism (Sevitt and Gallagher 1959; Eskeland, Solheim and Skjørten 1966; Moser and LeMoine 1981). Effective prophylaxis is not always provided for these patients and there is no consensus of opinion as to the best method (Morris 1980; Brenkel and Clancy 1989; Laverick, Croal and Mollan 1991).


The use of warfarin presents practical problems due to the need for regular monitoring. Bleeding complications and drug interactions reduce the ratio of benefit to risk of this form of prophylaxis.

Physical methods would seem to offer an attractive alternative, with their intrinsic safety and freedom from bleeding complications. Devices using inflatable cuffs which squeeze the calf have been shown to reduce the overall incidence of thrombosis after total hip replacement, but have proved less effective in protecting against the dangerous proximal thromboses which still occur in 15% of such patients (Paiement et al 1987; Hull et al 1990).

In 1983, Gardner and Fox described the haemodynamic significance of a physiological pumping mechanism in the foot. On weight-bearing a venous plexus in the sole is rapidly emptied into the deep veins of the legs. The flow produced by walking is pulsatile and flushes out the valve pockets in which thromboses are thought to originate.

The A-V Impulse System (Fig. 1; Novamedix, Andover, England, distributed by Howmedica International) was developed to compress the venous plexus artificially and it has been shown to be as effective as normal walking in activating the physiological foot pump (McMullin et al 1989). It reduces post-traumatic pain and swelling (Gardner et al 1990) and, in elective orthopaedic surgery, effectively decreases proximal deep-vein thrombosis. After total hip replacement the incidence of proximal thrombosis was reduced from 32.5% to 5% (Fordyce and Ling 1992) and after total knee replacement from 18.7% to 0% (Wilson et al 1992).

Swelling of the leg is a common complication of hip
fracture and, although not hazardous to the patient, it can cause discomfort, hinder early mobilisation and produce joint stiffness. Its control and reduction are therefore desirable.

We have evaluated the A-V Impulse System for the prevention of proximal deep-vein thrombosis after hemiarthroplasty for displaced subcapital fractures of the neck of the femur. We also studied the relative contributions of the trauma of the fracture and the effects of immobilisation to swelling of the leg, and the effect of the A-V Impulse System in diminishing it.

PATIENTS AND METHODS

Between August 1990 and February 1991 we allocated randomly all patients admitted to the Queen Alexandra Hospital with Garden stage IV subcapital fractures (Barnes et al. 1976), either to a treatment or to a control group. The only exclusion criteria were a previous history of deep-vein thrombosis, pulmonary embolism, chronic venous insufficiency or the presence of a malignant tumour. All patients gave their informed consent.

Before operating, we measured the circumferences of both legs, 10 cm above the upper poles and 10 cm below the lower poles of the patellae. Graduated compression stockings were then applied to both legs in both groups.

The operations were carried out at the earliest opportunity, usually within 24 hours of admission. Under general or spinal anaesthesia, we performed a hemiarthroplasty using an uncemented Thompson prosthesis. The Liverpool approach to the hip (Osborne 1987) was used with the patient in the lateral position. Postoperatively, the patients in the treatment group were immediately fitted with the A-V Impulse System. The inflatable pad was applied under the plantar arch and around the foot on top of the compression stocking, and held in place by a retaining slipper. The pad was connected to an electrical air-impulse generator, which inflated it in less than half a second and deflated it fully after three seconds. The cycle was repeated every 20 seconds. The pump functioned continuously night and day for seven to ten days while the patient was in bed or sitting at rest. The pad and the compression stockings were removed daily for inspection of the feet and the skin of the legs.

All patients in both groups had similar postoperative management. They were mobilised as soon as possible, usually on the second postoperative day. No anticoagulant drugs were given.

The calf and thigh circumferences were measured on the third postoperative day on both legs and again on the same day as the Doppler assessment of the proximal venous system, usually between seven and ten days after operation. A Doppler method modified from that of Barnes (1982) was used and all the ultrasound assessments were carried out by one of two experienced technicians. The assessments were performed in conjunction with augmentation tests of respiration, and proximal and distal limb compression. Proximal thrombosis was identified on the basis of clear Doppler ultrasound evidence. Patients in the treatment group had the A-V Impulse System removed before assessment.

Statistical analysis of the data on deep-vein thrombosis was carried out using Fisher’s exact test. The data on swelling of the leg were analysed using paired and unpaired (two sample) t-tests.

RESULTS

Eighty patients completed the trial, and the groups were well matched with regard to sex, age, type of anaesthesia and duration of operation (Table I).

Two patients, who initially entered the trial, were excluded. One, in the treatment group, found the foot pump unacceptable and another, in the control group, died from pulmonary embolism before the Doppler ultrasound assessment.

In general, the A-V Impulse System was well tolerated by the patients and caused few problems. In the early part of the trial four patients suffered dorsal foot sores. An improved design of slipper was then introduced; this was more comfortable and easier to apply and there were no further complications.

Deep-vein thrombosis. In the control group of 39 patients there was clear evidence of proximal deep-vein thrombosis in nine patients (23%). None of the 40 patients in
the treatment group had Doppler evidence of such thromboses. This difference was significant at $p < 0.01$.

Postoperative swelling. The results of the measurements of leg swelling are given in Tables II and III. Table II shows the swelling of the operated leg compared with the non-operated leg in the control group to indicate the relative influence of immobility and trauma. At three days postoperatively there was no significant difference in the calf, but in the thigh there was a significant increase in the diameter of the operated leg. By the seventh to tenth day the difference had further increased.

Table III shows the postoperative reduction in swelling in the thigh and calf of the operated legs of those using the A-V Impulse System compared with those of the control group. In the treated group, there was a mean reduction of 2.36 cm in thigh circumference at three days postoperatively and a mean reduction of 3.27 cm at seven to ten days ($p < 0.001$). In the calf there was a mean reduction of 1.25 cm in swelling at three days and a mean reduction of 1.55 cm at seven to ten days postoperatively ($p < 0.001$).

There were no bleeding complications in either the control or treated groups.

**DISCUSSION**

An incidence of approximately 24% of proximal-vein thrombosis after hip fracture has been reported (Culver et al 1970; Hamilton et al 1970). Several studies have shown that thrombosis in the femoropopliteal veins creates a significant risk of pulmonary embolism, in contrast to thrombosis below the knee which seems to have little clinical significance (Kakkar et al 1970; Moser and LeMoine 1981; Hull, Raskob and Hirsch 1986; Dorfman et al 1987). The incidence of fatal pulmonary embolism after operation for a fractured hip without prophylaxis is higher than for total hip arthroplasty (Haake and Berkman 1989). Our primary aim was to prevent potentially life-threatening proximal deep-vein thrombosis.

The method for diagnosing proximal thrombosis used in this study is open to criticism. It was selected for several reasons. The study was done in a busy hospital where Doppler ultrasonography is routinely carried out at the bedside by experienced technicians. We thought it difficult to justify the use of contrast venography with its attendant risk, discomfort and impracticality in frail and elderly patients. The Doppler ultrasound technique that we used has been validated for the detection of proximal thrombosis, giving in experienced hands a sensitivity of 92% to 96% and a specificity of 91% to 93% when compared with venography (Dosick and Blakemore 1978; Hanel et al 1981). It has been shown to be of value particularly in the detection of recent thrombosis (Sigel et al 1972). While it is almost certain that Doppler ultrasonography will have failed to detect some small non-occlusive thrombi, our results in the control group are in close agreement with those of two other studies which have shown an incidence of proximal thrombosis without prophylaxis of 24% and 22% (Culver et al 1970; Hamilton et al 1970).

It is clear from the reduction of proximal deep-vein thrombosis from 23% in the control group to 0% in the treatment group that the A-V Impulse System is effective in reducing the incidence of thrombosis after hip fracture.

Our study has shown that swelling of the thigh after
hip fracture arises both from the immobility resulting from bed rest and from the trauma of the fracture and the operation. In the calf, the swelling appears to result mainly from immobility. The A-V Impulse System produced significant reductions in the total swelling resulting from both causes.

Conclusion. The results of this study, the first of its kind to our knowledge, show that the A-V Impulse System is an effective device for the prevention of postoperative proximal deep-vein thrombosis and for the reduction of swelling in elderly patients after hemiarthroplasty for femoral neck fractures. The device proved simple to use and was well tolerated by the patients.

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REFERENCES


