The influence of intramedullary nailing upon the development of metastases in the treatment of an impending pathological fracture: an experimental study

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An experimental model has been developed in which the effects of a pathological fracture and intramedullary nailing on metastatic spread have been investigated. The endpoint used was the production of lung metastases in rats inoculated intracortically with a rhabdomyosarcoma. We have found that a pathological fracture markedly increases the incidence of lung metastases and that intramedullary nailing, by decreasing the incidence of fractures, decreases the incidence of lung metastases. The surgical procedure itself does not increase the incidence significantly. It is concluded that in metastatic disease prophylactic nailing of an impending pathological fracture is the treatment of choice.

Introduction

Rieder and Schumann [17] discussed a patient who developed a pathological fracture, due to metastasis of carcinoma of the breast. This fracture was treated by means of an intramedullary nail, after which the patient developed lesions in the trochanteric area. Based on this finding, the authors suggested that this surgical intervention had a metastasis-promoting effect. Haase [8] similarly reported that tumour cells were disseminated by a Küntscher nail inserted for a pathological femur fracture in a case of metastatic hypernephroma. These case reports and the publications of Peltier [15, 16] have popularized the hypothesis of acceleration of metastatic growth by intramedullary nailing. However, there is no experimental evidence and there are also insufficient clinical data on which to base this supposition. The advantages of doing an internal fixation are potentially great if it can be shown that no significant increase in metastases follows. Because we were interested to see if internal fixation of an impending pathological fracture has a metastasis-promoting effect, and whether other factors (e.g. fracturation) could play a significant role, we developed an animal-experimental model to investigate the influence of internal fixation on metastases formation.

Material and methods

Tumour

The rhabdomyosarcoma had arisen in the jaw musculature of an irradiated WAG/Rij rat in 1962. After alternate culturing in vitro and inoculation of cultured cells from selected clones with uniform growth patterns into young animals, a transplantable tumour system designated as R-1 and with constant growth...
characteristics resulted. The tumour volume-doubling time is approximately 4 days [1]. A total of 96 male (WAG/Rij x BN/Bi-Rij)F1 rats aged 22–28 weeks were inoculated on day 0 with sarcoma tissue. The tumour material weighing ±5 mg was inserted intramedullary at the level of the intermediate and distal third of the right femur as follows. After the lateral part of the femur was dissected free over a distance of ±1 cm, a hole 2 mm in diameter was drilled into the lateral cortex. This was followed by excocleation of the bone marrow over a distance of ±0.5 cm with a bent probe, thus forming an intramedullary cavity. Then a 5 mg piece of tumour was inserted. The defect in the cortex was closed with bone wax and the skin with clamps. The inoculation was performed under general ether anaesthesia.

**Osteosynthesis**

As intramedullary pins, disposable injection needles with filed point (Terumo 18 G x 1½) were used. The technique was as follows. Through a small incision, the abductors were split and the top of the major trochanter was cleared. The next step was to drill the bone cortex with a 1.2 mm drill. A space was then made in the bone marrow with disposable 23 G and 21 G diameter injection needles. The osteosynthesis was finally performed by inserting a needle with a filed point. The part of the needle above the major trochanter was cut off. After this procedure, the muscles were joined with catgut stitches and the skin finally closed with clamps.

**Exarticulation**

After tying the large vessels in the groin, the hip joint was approached surgically from its medial aspect. The head of the femur was dislocated from the acetabulum and the muscles attached to the femur were cut off at the origin. The skin was closed with clamps. All surgical procedures were performed under general ether anaesthesia.

**Endpoints and statistical evaluation**

The tumour-bearing leg was radiographically monitored every two weeks (figure 1). For the determination of lung metastases, rats were sacrificed. As by sacrificing the animals at too early a stage many lung metastases that were present but too small could have passed unnoticed, and as too late a sacrifice could have resulted in premature death due to massive lung metastases, 50 per cent were killed and examined for lung metastases on day 121 and the rest on day 156. The lungs were fixed in Bouin's solution and the number of visible metastases on the surface (magnified 4 times) was established. At the same time, all right femurs of animals without demonstrable lung metastases were examined histologically for the presence of rhabdomyosarcoma. Regional lymph node metastases or metastases in other organs were never observed. A total of 14 out of 96 rats were excluded from the final analysis: eight of these did not develop tumour growth and the tumour inoculation in six was apparently not properly performed, as they developed tumour extending into the soft tissue of the leg within 14 days after inoculation. Fisher's test was used for statistical evaluation.