Radiotherapy is an important and potentially curative treatment for malignancies of the cervix, endometrium, vagina, vulva, rectum, anus and penis. Successful treatment requires a combination of external beam x-ray and brachytherapy. Brachytherapy (brachy=short, therapy=treatment) is the placement of radioactive sources within the body cavities such as the uterus and vagina (intracavity brachytherapy), or within the tissues (interstitial brachytherapy). It allows an extremely high dose of radiation to be received by the tumour, with relative sparing of the surrounding tissues from radiation-induced complications.

The anaesthetist is a vital member of the brachytherapy team. Many of the patients are medically unfit for surgery. The radioactive sources are potentially very painful and can remain in situ for several days. During this time, the patient is nursed in an isolated room to reduce the radiation exposure to staff. The use of appropriate analgesic techniques can reduce these treatments from being an ordeal to slightly unpleasant.

Intracavity brachytherapy for cervical and endometrial cancers

Cervical cancer

Over the last 10 yr, cervical screening programmes and a rise in the standard of living has led to a fall in both prevalence and mortality from carcinoma of the cervix. In 1998, there were over 3500 new cases in the UK and 13 700 cases in the USA. However, it is still extremely common in the developing world where it is the most common female cancer.

Stage 1B tumours (confined to cervix) can be treated by Wertheim’s hysterectomy with cure rates of 85–90%. Patients considered unfit for surgery can be treated by radical radiotherapy with identical cure rates, but lower morbidity than surgery. More advanced stage tumours are treated by radiotherapy. Since cervical cancer is relatively slow to metastasize from the pelvis, it is possible to cure 40% of stage 3B tumours (fixed to one or both pelvic side walls). Recently, it has been shown that chemotherapy given along with pelvic brachytherapy reduces the risk of death by 30–50% compared to patients treated by radiotherapy alone. This significant advance may increase the number of patients referred for radiotherapy.

Endometrial cancer

The treatment of choice for most patients with endometrial cancer is simple hysterectomy, with cure rates of 80–90% if the tumour is confined to the uterus. In patients considered unfit for surgery, intracavity brachytherapy can result in a 5-yr survival of up to 73%.

Intracavity brachytherapy techniques

Manualy inserted radiation sources provide ‘gold standard’ treatment results at the expense of radiation exposure of staff. To reduce these risks, most centres in Europe now use remote after-loading systems. Aluminium and nylon applicators are inserted into the uterus and vagina under anaesthesia (Figs 1 and 2). Pneumatic hoses are connected to the applicators postoperatively, allowing stainless steel pellets (containing caesium in glass) to be moved in and out of the applicators from a computer-controlled lead safe. This can reduce the radiation exposure of nursing staff by 30-fold.

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After-loading systems deliver radiation at either high dose rate (HDR) in just a few minutes or at low dose rate (LDR) over 15–72 h. In 1994, a survey of UK practice found 97% of all departments used LDR but 41% planned to introduce HDR machines.13 HDR and LDR treatments have markedly different anaesthetic and analgesic requirements.

**High dose rate**

HDR treatment can be completed in a few minutes and performed on an outpatient basis. General anaesthesia, spinal anaesthesia23 or conscious sedation with fentanyl and midazolam33 are sufficient. Once the applicators are withdrawn, there are no further analgesic requirements.

Two methods have been described which avoid repeated anaesthesia for serial treatments. First, an indwelling cervical sleeve can be inserted under anaesthesia during the initial treatment. This can remain in situ to allow subsequent introduction of uterine applicators without anaesthesia. However, 26% of patients still experienced severe uterine pain which was relieved by nitrous oxide.37 Second, osmotic dilators can be introduced to dilate the cervix 10–12 h before insertion of the applicators. Discomfort is minimal with fentanyl and midazolam supplementation.18 Both methods are particularly useful in medically unfit patients.

**Low dose rate**

Following anaesthesia for insertion, the applicators remain inside the uterus and vagina for 15–72 h during LDR treatment. The postoperative care of these patients is complicated by many factors:

**Patient characteristics**

Typical patients presenting for pelvic brachytherapy vary from younger, fitter cases of cervical carcinoma (75% ASA I–II) to older, medically unfit cases of endometrial carcinoma (83% ASA III–IV).29 The most striking feature in younger women is the marked anxiety and distress produced by the nature of the underlying condition.34 In contrast, a series of 96 endometrial cases noted multiple risk factors (Table 1),3 with another series noting an average body mass index of almost 50 kg m⁻².24

**Type of pain**

The cause of considerable discomfort is multifactorial. The presence of applicator rods in the body of the uterus stimulates sympathetic autonomic afferents which enter the spinal cord at the T10–L1 level. This produces poorly
localized, central, lower abdominal pain of a cramping nature associated with nausea and vomiting. Distension of the cervix and upper vagina stimulates parasympathetic autonomic afferents from the pelvic splanchnic nerves of S2–4 to cause lower back pain. Vaginal packing and its retaining suture through the labia stimulates somatic afferents via the pudendal nerves of S2–4. Patients have a urinary catheter, and a rectal marker is initially present until the correct position of the applicators is confirmed by postoperative x-ray. All these stimuli are considerably worsened by patient movement. This occurs on transfer from the operating table to the transfer trolley and bed, on attachment of pneumatic hoses from the after-loading device and the removal of applicators some 20 h later. During this prolonged treatment the patient must lie still in bed, which can result in considerable pain and stiffness in up to 80% of cases.12

Postoperative environment
This often comprises an isolated single room. Close supervision is severely limited by the need to avoid radiation exposure to staff. Adequate monitoring of pain and vital signs is hampered by the need to interrupt treatment for recordings, as well as by equipment and staffing levels on the ward.

Analgesia for low dose rate intracavity brachytherapy
There is little published evidence on analgesic techniques for LDR pelvic brachytherapy. What mention there is originates from the oncology literature and this probably reflects the relatively small numbers of patients managed in any particular unit. In light of the factors complicating postoperative care, the following analgesic options can be considered.

Inhalational analgesia
Inhalational analgesia from nitrous oxide is well suited for the short term discomfort of applicator attachment, patient movement or applicator removal (where there is a sudden increase in pain many hours after other modes of analgesia have ceased to have an effect).37 It is easily administered, well tolerated and effective if used in anticipation of the stimulus.

Non-steroidal anti-inflammatory drugs and simple analgesics
Non-steroidal anti-inflammatory drugs (NSAIDs) and simple analgesics (including codeine phosphate as a routine constipating agent) contribute to a multimodal approach. In particular they may ease the cramping central abdominal pain, which many patients relate to menstrual pain. The use of NSAIDS may reduce the requirement for systemic opioids, as seen in other forms of gynaecological surgery.21

Systemic opioids
It is difficult to meet the wide variation in dose requirements via the intramuscular root (morphine requirements in young patients have exceeded 30 mg in the first 4 h of treatment in our unit). Such administration consumes a considerable amount of nursing time, frequently interrupts treatment and risks significant breakthrough pain. Patient-controlled analgesia (PCA) is a useful alternative in this setting, and its general advantages have been well described elsewhere. The degree of control given to the patient is helpful in enabling them to cope. Having a favourable respiratory depressant profile in comparison with other opioid techniques is a particular advantage in the isolated setting. Sedation, commonly referred to as a side effect, can be regarded as beneficial in such highly anxious patients. PCA requires regular monitoring assessments which interrupt treatment, unless remote alarmed monitoring is available.

As pelvic brachytherapy is a form of gynaecological surgery often performed on young women, it is no surprise to find that postoperative nausea and vomiting (PONV) can be problematic in the presence of systemic opioids. Although prophylactic antiemetics are of value,16 the incidence of PONV in published series varies from 25 to 50%.4 16 34 It occurs despite the avoidance of opioids and with the use of topical or regional anaesthesia for applicator insertion. In a study where systemic opioids were used, up to 47% of patients were not fit for discharge at the end of treatment due to PONV, dizziness and unsteadiness.10 In our unit this is a particular problem when patients who require large amounts of PCA morphine are mobilized on the morning following treatment. We believe this to be exacerbated by perioperative dehydration. Patients are fasted for anaesthesia, and remain supine and potentially nauseous during 20 h of treatment, resulting in reduced oral intake for up to 32 h prior to mobilization. Routine perioperative i.v. fluids are recommended.

Sedation
Sedation, often with fentanyl and midazolam, although not strictly speaking an analgesic technique, is frequently utilized in HDR therapy.24 33 In LDR therapy, benzodiazepines are often used to alleviate distress and promote sleep during protracted treatment in younger, more anxious patients.12 Indeed, 21 h of target-controlled propofol sedation has been described.26 This technique demanded

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Incidence (%)</th>
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<tbody>
<tr>
<td>Hypertension</td>
<td>50</td>
</tr>
<tr>
<td>Age &gt;75 yr</td>
<td>40</td>
</tr>
<tr>
<td>Morbid obesity</td>
<td>30</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>30</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>20</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>10</td>
</tr>
<tr>
<td>Thromboembolism</td>
<td>10</td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>10</td>
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</tbody>
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Table 1 Incidence of medical risk factors in patients with endometrial cancer
considerable monitoring and staffing resources (comprising an anaesthetist with remote monitoring, continuously present in an adjoining room), which were only deemed justifiable in an exceptional case. There is a balance to be struck between opioid and benzodiazepine use which reflects individual patient requirements. Oncology nurses are particularly experienced in making this judgement.

**Local anaesthesia**
Paracervical block is mentioned in only a few cases with no real indication of its effectiveness.\(^{18,20}\) The topical placement of 10% lidocaine 4 ml on the cervix and vagina has been evaluated in HDR therapy.\(^{13}\) The reduction in visual analogue scores from 60 mm (SD 24.8) to 49.9 mm (24.1) was significant. However, moderate pain still remained and the effects would not be of sufficient duration for LDR therapy.

**Caudal epidural block**
This is used in our unit. A standard approach with 0.375% bupivacaine 20 ml is well tolerated and produces minimal leg weakness. We are currently evaluating the contribution of the block due to the frequent requirement for supplemental opioids. This may be due to several factors. From the innervation of the structures involved, we expect analgesia of the cervix and vagina to be produced, but not sufficient to tolerate the presence of applicator rods in the body of the uterus. The block may be difficult to perform in obese patients and the failure rate is known to increase with age.\(^7\) Classical sacral anomalies are well described and have been confirmed recently by magnetic resonance imaging.\(^5\) Finally, the block may well be of insufficient duration (which may be due to the dose of bupivacaine used), despite the majority of analgesic demand occurring in the first 4 h of treatment.

**Lumbar epidural block**
This would seem ideally suited to the treatment of pain produced by LDR therapy. A low concentration local anaesthetic/opioid infusion, as is popular in many obstetric units, should provide excellent postoperative analgesia and could be topped up for applicator removal at the end of treatment. The use of such a technique has been described, albeit indirectly, in a recent study.\(^11\) Twenty pelvic brachytherapy patients were given epidural anaesthesia for applicator insertion, followed by postoperative infusion of 0.125% bupivacaine with fentanyl 3 µg ml\(^{-1}\). Patients were only assessed twice daily for block height and motor weakness. Although precise details were not given, all patients received adequate pain relief with minimal systemic opioids. The otherwise infrequent mention of epidural use in the literature\(^{10,16,20}\) may support our concerns over its safety for high risk cases in an isolated setting with limited supervision and monitoring.

**Interstitial brachytherapy for anal, low rectal, vaginal, vulval and penile cancers**

**Anal and low rectal cancers**
In the last decade, it has been clearly shown that anal cancer can be treated at least as well by radiotherapy as by the much more radical treatment of abdomino-perineal resection. Squamous carcinomas up to 5 cm have a 3-yr survival of 93% following radiotherapy.\(^{35}\) Surgery is the treatment of choice for adenocarcinomas of the low rectum impinging on the anus. However, radiotherapy can treat tumours extending to 8 cm beyond the anal margin. The 3-yr survival in patients who either refused surgery, or were judged inoperable on technical or medical grounds, was 57%.\(^{35}\)

The technique involves implantation of up to eight hollow stainless steel needles, of up to 10 cm in length, around the anal canal. They are secured in a horse-shoe shaped, rigid plastic template to ensure near perfect geometrical distribution of radiation dose (Figs 3 and 4). Iridium wire is cut to size and inserted into the needles 1–2 h after the implant has been sited under anaesthesia.

**Vaginal and vulval cancers**
Vaginal cancer is becoming more common, often following successful treatment of cervical lesions. Tumours in the lower and middle thirds of the vagina can be treated in a similar fashion to anal cancer. The vulva tolerates radiation poorly, but localized iridium needles implanted for up to 7 days are useful for incompletely excised or inoperable tumours.

**Penile cancer**
The use of radiotherapy can avoid amputation of the penis for tumours of up to 4 cm. External beam radiotherapy provides an 80% cure rate,\(^{27}\) but many patients develop
complications such as fibrosis of the penile shaft, erectile dysfunction and urethral strictures. However, implanting the tumour-bearing area with iridium reduces the incidence of complications\(^1\) (Fig. 5).

**Analgesia for interstitial brachytherapy**

General or regional anaesthesia is required to site pelvic interstitial implants. Postoperative analgesia is greatly enhanced by appropriate selection of the following techniques.

**Caudal epidural block**

This provides excellent postoperative analgesia for patients having anal, vaginal, vulval or penile implants. The pudendal nerve (S2–4) supplies the perineum and pelvic floor through the inferior haemorrhoidal and perineal branches, and the penis or clitoris through their corresponding dorsal nerve branches. However, the pudendal nerve is not the only sensory nerve to the perineum. The labia majora, base of penis and scrotum receive mixed sensory innervation from the terminal branches of the ilioinguinal (L1) and genitofemoral (L1–2) nerves. The injection of 0.375% bupivacaine 20 ml through the sacral hiatus, would be expected to provide a sensory block to a maximum height of L1.\(^2\) More commonly, the block only reaches the lower lumbar roots, resulting in inadequate analgesia in a small number of patients whose tumour extends outwith the distribution of the pudendal nerve.

**Spinal ‘saddle’ block**

Spinal ‘saddle’ block with 0.5% hyperbaric bupivacaine 1.0 ml in the sitting position, is a useful alternative to caudal block when the sacral hiatus cannot be identified or the area of overlying skin is highly inflamed following recent external beam radiotherapy.

**Penile nerve block**

This is highly suitable for operations on the shaft, glans and foreskin of the penis. Since the penile urethra is supplied throughout its length by the perineal branch of the pudendal nerve, block of the dorsal nerve of the penis does not provide anaesthesia for catheterization or surgery for tumour involving the urethra. The dorsal nerve is easily blocked with 0.5% bupivacaine 20 ml at the route of the penis, as it emerges through the perineal membrane below the lower border of the pubic symphysis. Several techniques have been described, including medial or bilateral injections at the penile root, with an average block duration of 10 h.\(^3\) Continuous dorsal nerve anaesthesia has also been described.\(^9\)

**Local anaesthetic infiltration**

Patients with low rectal adenocarcinomas undergoing intraluminal irradiation do not need any form of analgesia and the treatment is performed in the outpatient department. If an iridium implant is used to give a booster dose to the tumour bed, then local anaesthetic infiltration is required.\(^2\)

**Sedation**

External beam radiation in the palliation of rectal cancer can be combined with laser therapy, to control local symptoms by debulking the intraluminal growth. Photocoagulation of the lesion is painful and patients require sedation with opioids and benzodiazepines.\(^2\)

**Pre-emptive analgesia**

The use of local anaesthetic blocks for interstitial brachytherapy in our unit has produced some interesting findings. Postoperative pain in anal cancer treatment can be markedly reduced for up to 2–3 days after implant insertion, by a single caudal injection. Analgesia lasting far beyond the expected duration of the block is also seen in patients with penile cancer who, following dorsal nerve block, have required no analgesia for the entire 7 days of implant
insertion. This contrasts greatly with patients not receiving local anaesthesia, who seldom achieve adequate pain relief despite repeated systemic opioids.

The precise mechanisms involved in these observations are unclear. Decreased activation of nociceptive afferents may occur if the insertion of interstitial needles releases fewer inflammatory mediators (e.g., prostaglandins, bradykinin, histamine) than a standard skin incision with subsequent suturing and wound tension. The reduced peripheral sensitization of nociceptive nerve endings would lessen any degree of primary hyperalgesia. Penile, vulval and anal implants receive few C-fibre autonomic afferents and the somatic afferents are effectively blocked by local anaesthetic techniques. This may be sufficient to prevent central sensitization in the spinal cord and avoid the development of secondary hyperalgesia during implant insertion. In more major surgery, however, the clinical trials investigating preemptive analgesia have been disappointing because the analgesic regimen is perhaps not profound or prolonged enough to prevent central sensitization in the spinal cord.1

Summary
Pelvic brachytherapy presents the anaesthetist with numerous challenges. Patients vary from highly distressed young adults, to the elderly with coincidental disease severe enough to preclude surgery. The painful radioactive implants remain in place for a number of days. Treatment in isolated rooms reduces radiation exposure to staff, but makes close postoperative monitoring difficult, so the analgesic technique should involve minimum risk to the patient. Although there is very little published evidence of specific analgesic techniques in this area, knowledge of these problems allows the anaesthetist to select appropriate systemic analgesics and regional blocks to provide safe and effective pain relief.

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