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Effectiveness of acute postoperative pain management: I. Evidence from published data

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Background. This review examines the evidence from published data concerning the incidence of moderate-severe and of severe pain after major surgery, with three analgesic techniques; intramuscular (i.m.) analgesia, patient controlled analgesia (PCA), and epidural analgesia.

Methods. A MEDLINE search of the literature was conducted for publications concerned with the management of postoperative pain. Over 800 original papers and reviews were identified. Of these 212 papers fulfilled the inclusion criteria but only 165 provided usable data on pain intensity and pain relief. Pooled data on pain scores obtained from these studies, which represent the experience of a total of nearly 20 000 patients, form the basis of this review.

Results. Different pain measurement tools provided comparable data. When considering a mixture of three analgesic techniques, the overall mean (95% CI) incidence of moderate-severe pain and of severe pain was 29.7 (26.4–33.0)% and 10.9 (8.4–13.4)%, respectively. The overall mean (95% CI) incidence of poor pain relief and of fair-to-poor pain relief was 3.5 (2.4–4.6)% and 19.4 (16.4–22.3)%, respectively. For i.m. analgesia the incidence of moderate-severe pain was 67.2 (58.1–76.2)% and that of severe pain was 29.1 (18.8–39.4)%. For PCA, the incidence of moderate-severe pain was 35.8 (31.4–40.2)% and that of severe pain was 10.4 (8.0–12.8)%. For epidural analgesia the incidence of moderate-severe pain was 20.9 (17.8–24.0)% and that of severe pain was 7.8 (6.1–9.5)%. The incidence of premature catheter dislodgement was 5.7 (4.0–7.4)%. Over the period 1973–1999 there has been a highly significant ($P<0.0001$) reduction in the incidence of moderate-severe pain of 1.9 (1.1–2.7)% per year.

Conclusions. These results suggest that the UK Audit Commission (1997) proposed standards of care might be unachievable using current analgesic techniques. The data may be useful in setting standards of care for Acute Pain Services.

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The Acute Pain Service is a relatively recent innovation, developed to improve the management of postoperative pain.[1] Among the earliest services were those in Kiel[2] and in Seattle.[1] The concept was given impetus in the early 1990s in the UK by the publication of a joint report by the Royal Colleges of Surgeons and Anaesthetists[3] and in USA by the publication of protocol for Investment in Health Gain[4] such that 73% of US hospitals had a pain service by 1994,[5] whilst in the UK 88% of hospitals had an established pain service by 1999.[6]

There is evidence that pain services affect morbidity and duration of hospital stay.[7] However, despite the vast amount published on acute pain there have been few if any attempts to establish standards of care for acute postoperative pain services, although a number of large audits have been published. In a brief reference to postoperative pain in 1997 the Audit Commission (UK) proposed a standard whereby less than 20% of patients should experience severe pain following surgery after 1997, and that this should ideally reduce to less than 5% by 2002.[8] It is not clear from the

Audit Commission document how these figures have been arrived at, nor how valid this standard might be. In the light of this recommendation we decided to review the published literature on acute pain management in order to establish the validity of the Audit Commission's proposed standard.

In the past, pain relief has been provided mainly by 'as required' intramuscular (i.m.) injections of opioids. More recently, intravenous (i.v.) patient-controlled analgesia (PCA) and epidural analgesia have become popular, as they are perceived as being more effective. However, pain and pain relief are just one aspect of the wide range of outcome variables with which pain services are interest. For a review to be comprehensive it should consider three broad areas of outcome, such as effectiveness, safety, and tolerability. Effectiveness can be inferred from pain scores and pain relief reports. The incidence of respiratory depression and hypotension may be indicative of the safety of the techniques whilst tolerability is reflected by the occurrence of nausea and vomiting, sedation, itching, and the need for urinary catheterization. Psychological effects such as nightmares/hallucinations and panic attacks may also be important.

Methods

Search strategy

We used MEDLINE (1966 onwards) to search the literature for all English language publications concerned with the management of postoperative pain and in particular measures of effectiveness. Keywords selected included analgesia, postoperative pain, pain therapy, i.v. PCA, and epidural analgesia. The computerized search identified keywords in the title, abstract, and medical subject headings (MESH). As standard bibliographic databases label incorrectly nearly 50% of published trials, we also 'hand searched' the full reference lists from review articles and individual relevant papers in peer-reviewed English language journals. Finally, a hand search of four anaesthetic journals (*Anaesthesia*, *British Journal of Anaesthesia*, *Acta Anaesthesiologica Scandinavica*, and *Anesthesiology*) from 1980 to 1999 was performed to cross check the quality of the retrieval method.

All publications identified by the search strategy were categorized according to the level of evidence obtained, based broadly on the criteria of the US Preventive Task Force (Appendix I). Subsequent analysis was not confined to randomized controlled clinical trials but included cohort studies, case control studies, and audit reports; that is level 2 and level 3 evidence. Case reports were not included, nor were authors approached for raw or unpublished data. No attempt was made to grade individual papers according to quality. All of the studies used in the analysis were given equal value. Data extraction was undertaken by one author (S.D.). Figure 1 summarizes the methodology.

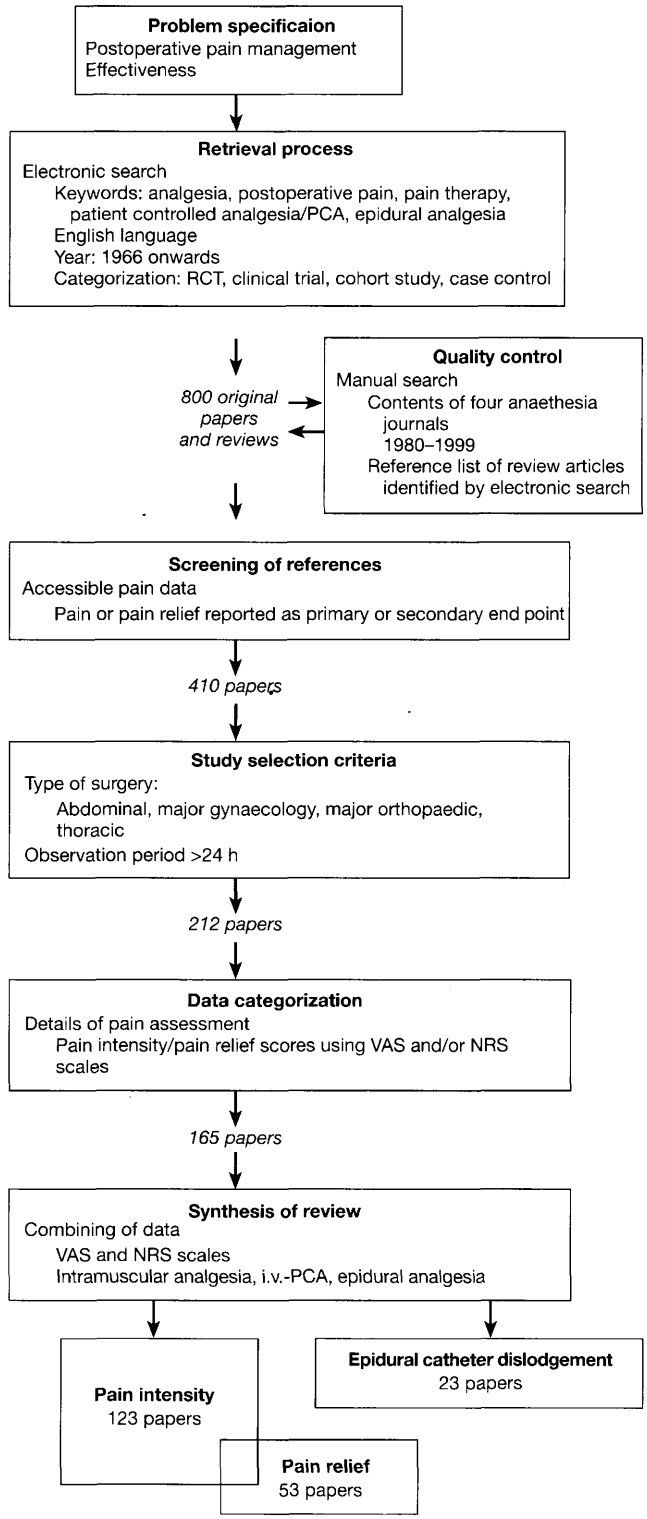

Fig 1 Postoperative pain management: data retrieval flow diagram.

Selection criteria

We included articles relating to abdominal, major gynaecological, major orthopaedic, and thoracic surgery. The shortest period of observation was 24 h. Initial observations

made in the recovery room were not included. We excluded articles relating to paediatric, day stay, and minor surgery and where the period of observation was less than 24 h. We did not include any study in which a mixed or unusual analgesic technique (e.g. ketamine, clonidine) was described. We did not include articles relating to intrathecal opioids because it is an infrequently used technique (in a Europe-wide survey epidural analgesia was used eight times more frequently than intrathecal analgesia[9]). Neither did we include studies of combined spinal/epidural analgesia nor articles relating to regional analgesic techniques such as interpleural, paravertebral, and lumbar plexus blocks for the same reason.

Definitions

We were interested in obtaining, from the published literature, the incidence of analgesic 'failure' after major surgery. Defining analgesic 'failure' would involve making a number of assumptions, and may differ between patients and medical staff. We have simply calculated the overall incidence of pain intensity in two categories: the percentage of patients who experienced moderate-severe pain and the percentage of patients who experienced severe pain at some time during the first 24 h. We calculated these incidences for each of the three analgesic techniques in common practice: i.m. analgesia, PCA, and epidural analgesia.

Information was extracted from published studies, which reported pain scores using any one of three different measures; visual analogue scale (0–100 mm), numerical rating scale (0–10), and verbal rating scales (mild/moderate/severe). The different measurements have been recorded and where studies involved comparison between drugs using the same technique (e.g. epidural opioids *vs* epidural local anaesthetics) the results have been pooled, to reflect what happens in clinical practice, such as a mixture of drug regimens. Where the study has compared analgesic techniques (PCA *vs* epidural) results have been recorded separately under each technique.

Studies used either contemporaneous pain assessments and/or retrospective pain assessments. For contemporaneous pain scores the worst score in the first 24 h was used, excluding recovery room. The percentage of patients with moderate-severe pain and with severe pain was recorded from each study and this figure was weighted by the number of patients in the study. Moderate-severe pain was taken as a visual score greater than 30/100 or a numerical score greater than 3/10 in this review, in common with most authors. In many but not all studies it was possible to obtain a separate figure for the percentage of patients experiencing severe pain, which was taken as pain intensity score of greater than 70/100 or 7/10. Only when pain intensity scores were reported as raw data, as percentages with moderate or severe pain, or as histograms were we able to extract incidence data. The commonest reason not to include pain intensity data was when pain scores were presented as mean and standard deviation. As the pain scores were unlikely to be normally distributed it was impossible to obtain the percentage of patients experiencing moderate-severe pain and severe pain. Commonly, a single verbal score was recorded after 24 h, whereas visual scores were often recorded contemporaneously at intervals during the 24 h period.

Several studies reported not only pain but also pain relief. Escape criteria such as the need for additional 'rescue' analgesia was also reported in some studies. Most studies reported pain/pain relief at rest but there are some scales that combine pain at rest and on movement; these have been analysed separately.

A number of studies reported the incidence of premature catheter dislodgement, and as this was relevant to analgesic 'failure' this was included in the study. Occasionally the incidence of missed segments or unilateral blocks was reported, but this was insufficient for formal analysis.

Statistics

The mean percentage reporting a given level of pain was found by the method of weighted mean, weighting by the number of subjects in the group.[10] When patients were grouped by analgesic technique, some studies contributed subjects to more than one group. The presence of a few studies in more than one analgesic technique was ignored in the analysis, possibly resulting in a small loss of power. Where appropriate groups were compared using analysis of variance. The percentage of patients reporting pain was weighted by the number as described previously and this figure was used in the analysis rather than any other statistical transformation. This is because our main aim was to estimate the percentage reporting pain for the whole population. All analyses were done using Stata 5.0 (Stata Corp., College Station, TX).

Results

We identified over 800 original papers and reviews, 410 of which contained data that were suitable for the meta-analysis as a whole. Papers which fulfilled our inclusion and exclusion criteria, and from which we were able to extract usable data on pain intensity and pain relief (several papers had data on both) data totalled 212. Some papers contributed both pain intensity and pain relief data. This resulted in 222 papers as follows: i.m. analgesia 45 papers (Appendix II), PCA 73 papers (Appendix III), and epidural analgesia 104 papers (Appendix IV). Pain intensity results were obtained from 123 papers, which included a total of 19 909 patients, published between 1973 and 1999. Pain relief results were obtained from 53 papers, which included 9068 patients published between 1972 and 1998. The incidence of premature epidural catheter dislodgement was obtained from 32 papers, which included 13 629 patients, published between 1975 and 1998 (Appendix V).

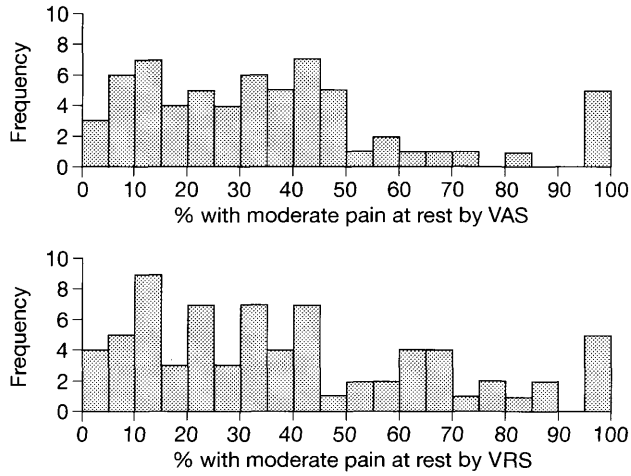

Fig 2 Frequency distribution (numbers of papers) reporting moderate-severe pain at rest as measured by visual and verbal scales. There were no differences between these two methods of pain measurement.

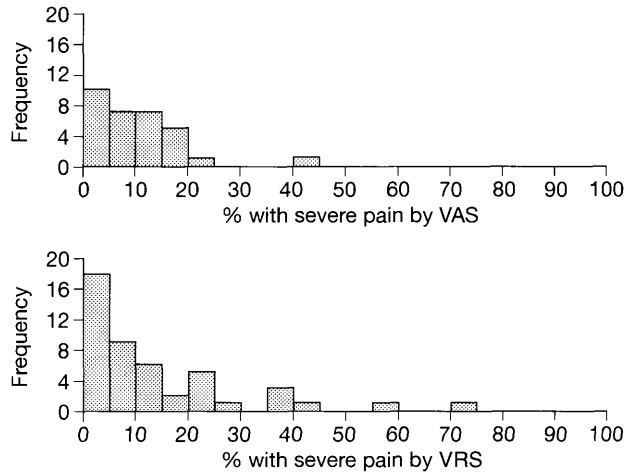

Fig 3 Frequency distribution (numbers of papers) reporting severe pain at rest as measured by visual and verbal scales. There were no differences between these two methods of measuring pain.

Pain intensity

We initially analysed visual and verbal scales separately. Visual or verbal scales produced similar distributions for the percentage of patients having moderate or greater pain (Fig. 2). The corresponding distributions for severe pain are shown in Figure 3. Visual and verbal pain scales were compared using analysis of variance and there were no significant differences between the distributions.

Table 1 shows the percentage of patients experiencing moderate-severe and severe pain for both visual and verbal scales, and when both scales were combined. These results were similar for both scales and when considered together with the analysis of the distributions in Figures 2 and 3, we felt that it was statistically valid to regard the distributions of visual and verbal scales as coming from the same population. Subsequent analysis was therefore conducted on the combined data, allowing the maximum possible number of studies to be used.

The overall mean percentages reporting pain in the three analgesic techniques, weighted for study size, are shown in Table 2: the percentage reporting moderate-severe pain at rest is thus estimated to be between 26 and 33%. Severe pain was reported by between 8 and 13% of patients in the first 24 h after major surgery.

As part of the analysis we looked at how the incidence of pain altered between 1973 and 1999. The analgesic technique reported varied with year of publication (Table 3). In the early part of the period of the analysis, i.m. analgesia was the most frequently reported technique, whereas in the later part epidural analgesia was the most frequent. Between 1973 and 1999 there was a significant fall in the overall incidence of moderate-severe pain at rest ($P<0.0001$), by 1.9% per annum (95% CI 1.1–2.7). When the relationship between percentage reporting moderate-severe pain and year of publication was adjusted for analgesic technique, the relationship with time was no longer significant ($P=0.7$) and the estimated fall was reduced to 0.2% per annum (95% CI –0.6 to 0.9). The effect of analgesic technique was highly significant ($P<0.0001$), indicating that as epidural analgesia was introduced postoperative analgesia improved over time.

The incidence of moderate-severe pain and severe pain by analgesic technique is shown in Table 4. Epidural analgesia resulted in the smallest percentage reporting both moderate-severe incidence for pain and severe pain, while i.m. analgesia resulted in the highest percentage. Moderate-severe pain on movement was unreliable, because pain on movement was not commonly reported except in studies of epidural analgesia, with resulting wide confidence intervals. There were no differences between analgesic techniques in the relative numbers of studies based on type of surgery (gynaecological, abdominal, orthopaedic, and thoracic).

Pain relief

Nearly all pain relief was recorded using a verbal rating scale (good, fair, poor) and were generally retrospective, so we have not separated the methods of recording. The results are shown in Table 5.

Overall, between 2 and 5% of patients reported poor pain relief and between 16 and 22% reported only fair-to-poor pain relief. While poor pain relief was most frequently reported by patients receiving epidural analgesia, the numbers of papers was small with wide confidence intervals.

Over the period 1972–1998 significantly fewer patients reported poor pain relief ($P<0.04$), a decrease of 0.4 (95% CI 0.1–0.6) percentage points per year. When adjusted for analgesic technique the relationship was no longer significant. However, the proportion reporting fair-to-poor pain relief was unchanged over time.

Table 1 Percentage of patients reporting moderate-severe pain or severe pain as measured by the three different pain scales, unweighted for study size. VAS=visual analogue scale; VRS=verbal rating scale

	Number of studies	Mean (%) reporting pain	Standard deviation	Range	
				Min	Max
VAS pain score only					
Moderate-severe at rest	64	35	26	0	100
Moderate-severe on movement	25	44	31	0	95
Severe	31	9	9	0	44
VRS pain score only					
Moderate-severe at rest	73	39	28	0	100
Moderate-severe on movement	9	38	29	0	78
Severe	47	13	16	0	73
Combined VAS and VRS pain score					
Moderate-severe at rest	136	37	27	0	100
Moderate-severe on movement	33	41	30	0	95
Severe	78	11	14	0	73

Table 2 Percentage of patients reporting moderate-severe pain or severe pain, as measured by all three pain scales combined, weighted for study size. VAS=visual analogue scale; VRS=verbal rating scale

Combined VAS and VRS pain score	Number of studies	Mean (%) reporting pain	Standard error	95% Confidence interval
Moderate-severe at rest	136	29.7	1.7	26.4–33.0
Moderate-severe on movement	33	32.2	3.7	24.8–39.6
Severe	78	10.9	1.3	8.4–13.4

Premature epidural catheter dislodgement

We have confined our analysis to the incidence of catheter loss as we felt that unilateral block and missed segment represented technical difficulties with instigating the block. The overall mean (95% CI) incidence of premature epidural catheter dislodgement based on 13 629 patients from 32 studies was 5.7 (4.0–7.4)%.

Table 3 Numbers of published studies by year of publication. i.m.=intramuscular; PCA=patient-controlled analgesia

Publication date	Method of analgesia			Total
	i.m.	PCA	Epidural	
Pre 1974	1	0	0	1
1975–1979	0	1	2	3
1980–1984	5	4	1	10
1985–1989	14	9	18	41
1990–1994	11	19	27	55
1995–1999	0	16	23	39

Discussion

How much pain is acceptable after surgery? The evidence from this review indicates that the overall incidence of severe pain reported in the literature is 11%. This contrasts with the Audit Commission's (UK) recommendation that by 2002 less than 5% of patients should experience severe postoperative pain. However, when considering a standard of care for pain intensity case mix is important. Day surgery pain can result in mild or no pain that can be managed by relatively simple techniques and procedures including take-home oral analgesia and advice.[11] This review was limited to those operations after which moderate-severe post-operative pain could be expected, namely major abdominal gynaecological surgery, major orthopaedic surgery, and any laparotomy or thoracotomy.[12] Importantly, these operations would all be in the remit of the pain service and would generally require postoperative analgesia by i.m. analgesia, PCA, or epidural analgesia.

This review differs from a formal systematic review with meta-analysis in a number of respects. We did not confine ourselves to randomized controlled trials and no attempt was made to grade individual papers according to quality. All of the studies used in the analysis were given equal value as we were not concerned with the conclusion of the individual study merely the incidences of pain intensity. We feel that this approach is justified as we were not considering the results of published studies but were concerned with extracting the data from them. However, we did confine our search to English language publication because of the necessity to read in detail both the methods and results sections of each paper. This might be considered as a flaw although the large number of publications included will tend to reduce any tendency to bias. The hand search performed on four anaesthetic journals was designed to cross check the completion of the electronic search. As few new papers were picked up by this search method it was not extended to

Table 4 Percentage of patients reporting moderate-severe pain or severe pain by analgesic technique, weighted for study size. *Cannot be estimated as numbers are too small. i.m.=intramuscular; PCA=patient-controlled analgesia

Analgesic technique	Number of studies	Mean (%) reporting pain	Standard error	95% Confidence interval
Moderate-severe pain at rest				
i.m.	29	67.2	4.4	58.1–76.2
PCA	45	35.8	2.2	31.4–40.2
Epidural	62	20.9	1.6	17.8–24.0
Moderate-severe pain on movement				
i.m.	1	78.0	*	*
PCA	10	25.3	7.5	8.4–42.1
Epidural	22	37.9	3.6	30.4–45.4
Severe pain				
i.m.	21	29.1	4.9	18.8–39.4
PCA	27	10.4	1.2	8.0–12.8
Epidural	30	7.8	0.8	6.1–9.5

Table 5 Percentage of patients reporting fair-to-poor pain relief or poor pain relief by analgesic technique, weighted for study size. *Cannot be estimated as numbers are too small. i.m.=intramuscular; PCA=patient-controlled analgesia

	Number of studies	Mean (%) reporting pain relief	Standard error	95% Confidence interval
All subjects				
Poor	38	3.5	0.5	2.4–4.6
Fair-to-poor	47	19.4	1.5	16.4–22.3
% reporting poor pain relief				
i.m.	5	1.6	1.3	*
PCA	17	3.6	0.8	1.8–5.4
Epidural	16	5.2	0.7	3.7–6.8
% reporting poor or fair pain relief				
i.m.	12	21.3	3.5	13.6–29.1
PCA	16	16.7	2.2	12.1–21.3
Epidural	19	19.4	2.1	15.0–23.7

other journals. Data extraction was undertaken by one author, because we did not need to confer over quality of each study, simply extract reported incidence. A degree of heterogeneity is inevitable in a review of this type. However, we feel that the large numbers of studies included and the small number of differences sought will reduce the likelihood of statistical heterogeneity. Also, we were mindful of the dangers of over interpretation inherent in searching for causes of heterogeneity. Indeed, it has been suggested that over investigating heterogeneity may be likened to subgroup analysis in individual trials.[13] Nevertheless, we have simply reported incidences of pain intensity, and refrained from formal statistical comparisons between analgesic techniques. With respect to clinical heterogeneity we found that the surgical case mix of the studies used was not only very similar between the three analgesic techniques but was also similar to that reported by Moriarty and colleagues[14] and to the case mix of the Acute Pain Service in one of the authors' hospitals (Table 6). We feel confident therefore that these findings mirror 'clinical practice'.

Table 6 Surgical case mix of studies used in review: percent of papers published in each surgical discipline by analgesic technique compared with audit data. *Results of St George's Hospital Acute Pain Service audit 1998–1999 (unpublished)

Analgesic technique	Surgical discipline			
	General (%)	Gynaecology (%)	Orthopaedic (%)	Thoracic (%)
i.m.	59	13	10	18
PCA	69	17	12	2
Epidural	56	6	11	27
Moriarty *et al.*[14] (*n*=1660)	69	4	14	2
Audit data* (*n*=1571)	34	22	20	13

The evaluation of pain after surgery is complex. It is generally accepted that the visual analogue scale is more sensitive and more accurate in representing pain intensity than other single dimension pain scales. Nevertheless, verbal rating scales (mild/moderate/severe) are widely used clinically and have the advantage of reflecting some of the multidimensional nature of pain. There is evidence that visual and verbal scales are moderately well correlated.[15] Other pain scores such as Magill Pain Questionnaire are rarely used for acute postoperative pain.

Analgesic 'failure' has been described in various terms in different studies depending on which pain scale was used. Many studies using verbal rating scales regarded moderate

or severe pain in the postoperative period as representing inadequate analgesia. In studies that have used visual scales, scores more than 30/100 or 3/10, respectively, were the most frequently used scores indicative of inadequate analgesia.[17 18] Rarely lower scores (more than 20/100)[19] or higher scores (more than 50/100)[20] were used as endpoints to define inadequate analgesia. A visual score more than 70/100 was the most common endpoint to define severe pain, although more than 50 has been used.[21] Another group has proposed that moderate pain on verbal score equates to a mean visual score of 49 mm, whilst severe pain equates to a mean visual score of 75 mm.[16] Nevertheless, by analysing both visual and verbal scales separately we were able to demonstrate that, used in this way, these two scoring systems give broadly similar results, and can be used interchangeably.

A number of studies recorded pain both at rest and on movement. It is unclear whether patients distinguish between pain at rest and pain on movement. This may be influenced by such factors as presence of persistent cough, need for physiotherapy, dressing changes, etc. It is probable that, when patients are asked to rate pain over the previous 4 h or at the end of 24 h, they may not distinguish between pain at rest and pain on movement, but may give an overall assessment. It was interesting to note that measurement of pain on movement occurred mostly in studies involving epidural analgesia and seemed of less concern to authors reporting results for other techniques. There were sufficient data to calculate an overall incidence only for pain on movement for moderate-severe pain, but not for severe pain alone. It seems from the literature that pain on movement was reported relatively infrequently and the calculated incidence of pain was associated with wide confidence intervals. For this reason we have limited conclusions and recommendations to pain at rest, which was available for both moderate-severe pain and severe pain, and was associated with narrower confidence intervals.

A number of studies report not only pain intensity but also pain relief. Escape criteria such as the need for additional 'rescue' analgesia have also been reported in some studies. The literature on pain relief after major surgery reports a wide range of effectiveness of analgesic techniques. It was unclear how to interpret the incidence of pain relief, as opposed to pain intensity. There were sufficient studies to calculate incidence of fair-to-poor pain relief and poor pain relief but confidence intervals were relatively wide. The incidences of pain relief do not match the incidences of pain intensity, either overall or for each analgesic technique. It is possible that the incidence of pain intensity is a more direct measure, as pain relief will presumably vary with initial pain intensity.

Our findings that i.m. analgesia was associated with the highest percentage of patients experiencing inadequate analgesia support the general view that it is the least effective of the three techniques studied. Although using strict criteria for administration, i.m. analgesia can be an effective technique,[22 23] the literature suggests this does not occur in clinical practice. The rate of analgesia 'failure' after i.m. analgesia has received relatively scant attention in the literature; there were only 45 published articles (many acting as control groups for other techniques) with no large prospective studies as exist for both PCA and epidural analgesia. Epidural analgesia is generally considered more effective than PCA. Large prospective studies of epidural analgesia such as Scott report 17.4% analgesic failure[22] and Stenseth reported 24–37% of patients after laparotomy experienced analgesic failure by their criteria.[25] Our review indicates a lower incidence of moderate-severe pain and severe pain when epidural was used (20.9 and 7.8%, respectively) compared with PCA (35.8 and 10.4%, respectively). The epidural figures are undoubtedly confounded by technical failures such as premature epidural catheter displacement, which we found to have an incidence of 5.7%. Epidural analgesia does present some particular challenges to pain services. The rate of technical failure has been reported as high as 18.7% in the first 72 h.[25] In addition to premature catheter dislodgement, problems include unsuccessful placement, unilateral block, and missed segments. When these problems occur on postoperative wards there may be no back-up analgesia provided, and it may take time for the problem to be recognized and an appropriate response initiated.

We avoided any measures of patient satisfaction in this review, although some studies did report satisfaction rates. Satisfaction is complex and probably has contributions from many aspects of postoperative care, including effectiveness of analgesia, and perceived safety of analgesic technique and side-effects of treatment. While a number of studies have assessed patient satisfaction and measuring postoperative pain intensity, there was generally a poor correlation between the two. Patient satisfaction remains high even in the presence of moderate to severe pain.[17 26 27] The reasons for this are complex. Patients appear to expect some pain after surgery. Furthermore, in the presence of pain, patients are apparently satisfied by the fact that their health carers are attempting to provide pain relief even if the results are not always successful, as judged by postoperative pain scores. Satisfaction does not actually measure what happened after surgery, but only how satisfied the patient was about what happened. If patients are not aware that excellent postoperative pain relief is achievable then they may well be satisfied with less. Patients may not seek complete pain relief and so self-administer PCA to only moderate levels of pain relief.[28] In addition patients may report higher satisfaction for fear of offending those providing their postoperative care. Measuring patient satisfaction will, it seems, nearly always show high levels of satisfaction for pain relief after surgery, and it is not a particularly discriminating measure of success of a pain service.

In summary, we present a review of published data on the effectiveness of acute postoperative pain management from

which it has been possible to calculate the incidence of moderate-severe pain and of severe pain after major surgery for each of the three commonly used analgesic techniques. Assuming a mixture of analgesic techniques the overall incidence of moderate-severe pain was 30% and the overall incidence of severe pain was 11%. For i.m. analgesia the incidence of moderate-severe pain was 67% and that of severe pain was 29%. For PCA, the incidence of moderate-severe pain was 36% and that of severe pain was 10%. For epidural analgesia the incidence of moderate-severe pain was 21% and that of severe pain was 8%. The incidence of premature epidural catheter dislodgement was 6%. These incidences of pain are calculated weighted means and so it is possible to propose reasonable targets. We suggest that individual pain services should aim to achieve figures better than the above mean incidences. However, despite the significant reduction in the incidence of pain over time we would suggest that, based on these data, the UK Audit Commission's standard of less than 5% of patients experiencing severe pain after major surgery by 2002 may not be achievable.

Appendix I

United States Preventive Task Force levels of evidence

Level 1

Evidence obtained from systematic review of relevant randomized controlled trials with meta-analysis where possible (review with secondary data analysis).

Level 2

Evidence from one or more well-designed randomized clinical trial (RCT).

Level 3

Evidence from well-designed, non-controlled studies (prospective longitudinal study with/without specific intervention) or from well-designed case-controlled studies (retrospective study of a cohort with information pursued backwards in time).

Appendix II

References used to obtain incidences of moderate or greater pain—i.m.

Albert JM, Talbott TM. PCA versus conventional intramuscular analgesia following colon surgery. *Dis Colon Rectum* 1988; **31**: 83–6

Atwell JR, Flanigan RC, Bennett RL, Allen DC, Lucas BA, McRoberts JW. The efficacy of patient controlled analgesia in patients recovering from flank incisions. *J Urol* 1984; **132**: 701–3

Austin KL, Stapleton JV, Mather LE. Multiple intramuscular injections: a major source of variability in analgesic response to meperidine. *Pain* 1980; **8**: 47–62

Bennett R, Batenhorst R, Graves DA, Foster TS, Griffen WO, Wright BD. Variation in postoperative analgesic requirements in the morbidly obese following gastric bypass surgery. *Pharmacotherapy* 1982; **2**: 50–3

Bollish SJ, Collins CL, Kirking DM, Bartlett RH. Efficacy of patient controlled versus conventional analgesia for postoperative pain. *Clin Pharm* 1985; **4**: 48–52

Bourke DL, Spatz E, Motara R, Ordia JI, Reed J, Hlavacek JM. Epidural opioids during laminectomy surgery for postoperative pain. *J Clin Anaesth* 1992; **4**: 277–81

Brewington K. PCA in gynecological surgery. *Alabama Med* 1989; **Nov**: 15–17

Brown CR, Mazzulla JP, Mok MS. Nussdorf T, Rubin P, Schwesinger WH. Comparison of repeat doses of intramuscular ketorolac and morphine for analgesia after major surgery. *Pharmacotherapy* 1990; **10**: 45S–49S

Chen PP, Chui PT, Gin T. Comparison of ondansetron and metoclopramide for the prevention of postoperative nausea and vomiting after major gynaecological surgery. *Eur J Anaesthesiol* 1996; **13**: 485–91

Cohen FL. Postsurgical pain relief: patients' status and nurses' medication choices. *Pain* 1980; **9**: 265–74

Cronin M, Redfern PA, Utting JE. Psychometry and post-operative complaints in surgical patients. *Br J Anaesth* 1973; **45**: 879–86

Dahl JB, Daugaard JJ, Larsen HV, Mouridsen P, Nielsen TH, Kristoffersen E. Patient controlled analgesia: a controlled trial. *Acta Anaesthesiol Scand* 1987; **31**: 744–7

Donovan BD. Patient attitudes to postoperative pain relief. *Anaesth Intensive Care* 1983; **11**: 125–8

Eisenach JC, Grice SC, Dewan DM. Patient controlled analgesia following cesarean section; a comparison with epidural and intramuscular narcotics. *Anesthesiology* 1988; **68**: 444–8

Goudie TA, Allan WB, Lonsdale M, Burrow LM, Macrae WA, Grant IS. Continuous subcutaneous infusion of morphine for postoperative pain relief. *Anaesthesia* 1985; **40**: 1086–92

Gurel A, Unal N, Elevli M, Eren A. Epidural morphine for postoperative pain relief in anorectal surgery. *Anesth Analg* 1986; **65**: 459–502

Harrison DH, Sinatra R, Morgese L, Chung JH. Epidural narcotic and PCA for post cesarean section pain relief. *Anesthesiology* 1988; **68**: 454–7

Hasenbos M, van Egmund J, Gielen M, Crul JF. Postoperative analgesia by epidural versus intramuscular nicomorphine after thoracotomy. Part I. *Acta Anaesthesiol Scand* 1985; **29**: 572–6

Hasenbos M, van Egmond J, Gielen M, Crul JF. Postoperative analgesia by epidural versus intramuscular nicomorphine after thoracotomy. Part II. *Acta Anaesthesiol Scand* 1985; **29**: 577–82

Hasenbos M, van Egmond J, Gielen M, Crul JR. Postoperative analgesia by high thoracic epidural versus intramuscular nicomorphine after thoracotomy. *Acta Anaesthesiol Scand* 1987; **31**: 608–15

Hew E, Foster K, Gordon R, Hew-Sang E. A comparison of nalbuphine and meperidine in treatment of postoperative pain. *Can J Anaesth* 1987; **34**: 462–5

Hjortso NC, Neumann P, Frosig F, Andersen T, Lindhard A, Rogon E, Kehlet H. A controlled study on the effect of epidural analgesia with local anaesthetics and morphine on morbidity after abdominal surgery. *Acta Anaesthesiol Scand* 1985; **29**: 790–6

Jayr C, Thomas H, Rey A, Farhat F, Lasser P, Bourgain J. Postoperative pulmonary complications: epidural analgesia using bupivacaine and opioids versus parenteral opioids. *Anesthesiology* 1993; **78**: 666–76

Kalso E, Pertunnen K, Kaasinen S. Pain after thoracic surgery. *Acta Anaesthesiol Scand* 1992; **36**: 96–100

Kenady DE, Wilson JF, Schwartz RW, Bannon CL. A randomised comparison of PCA versus standard analgesic requirements in

patients undergoing cholecystetomy. *Surg Gynecol Obstet* 1992; **174**: 216–8
Kilbride MJ, Senagore AJ, Mazier WP, Ferguson C, Ufkes T. Epidural analgesia. *Surg Gynecol Obstet* 1992; **174**: 137–40
Kuhn S, Cooke K, Collins M, Jones JM, Mucklow JC. Perceptions of pain relief after surgery. *BMJ* 1990; **300**: 1687–90
Lange MP, Dahn MS, Jacobs LA. PCA versus intermittent analgesia dosing. *Heart Lung* 1988; **17**: 495–8
Langford R, Bakhshi K, Moylan S, Foster JM. Hypoxaemia after lower abdominal surgery: comparison of tramadol and morphine. *Acute Pain* 1998; **1**: 7–12
Logas WG, el-Baz N, el-Ganzouri A, *et al.* Continuous thoracic epidural analgesia for postoperative pain relief following thoracotomy. *Anesthesiology* 1987; **67**: 787–91
Mahoney OM, Noble PC, Davidson J, Tullos HS. The effect of continuous epidural analgesia on postoperative pain, rehabilitation and duration of hospitalisation in total knee arthroplasty. *Clin Orthop Related Res* 1990; **260**: 30–7
Nimmo WS, Todd JG. Fentanyl by constant rate intravenous infusion for postoperative analgesia. *Br J Anaesth* 1985; **57**: 250–4
Owen H, McMillan V, Rogowski D. Postoperative pain therapy: a survey of patients' expectations and their experiences. *Pain* 1990; **41**: 303–7
Powell H, Smallman JM, Morgan M. Comparison of intramuscular ketorolac and morphine in pain control after laparotomy. *Anaesthesia* 1990; **45**, 538–42
Power I, Noble DW, Douglas E, Spence AA. Comparison of intramuscular ketorolac and morphine for pain relief after cholecystectomy. *Br J Anaesth* 1990; **65**: 448–55
Raj PP, Knarr DC, Vigdorth E *et al.* Comparison of continuous infusion of a local anaesthetic and administration of systemic narcotics in the management of pain after total knee replacement surgery. *Anesth Analg* 1987; **66**: 401–406
Rawal N, Sjostrand U, Christoffersson E, Dahlstrom B, Arvill A, Rydman H. Comparison of intramuscular and epidural morphine for postoperative analgesia in the grossly obese. *Anesth Analg* 1984; **63**: 583–92
Rosenberg PH, Heino A, Scheinin B. Comparison of intramuscular analgesia, intercostal block, epidural morphine and on-demand intravenous fentanyl in the control of pain after upper abdominal surgery. *Acta Anaesthesiol Scand* 1984; **28**: 603–7
Searle NR, Roy M, Bergeron G, *et al.* Hydromorphone PCA after coronary artery bypass surgery. *Can J Anaesth* 1994; **41**: 198–205
Smythe MA, Zak MB, O'Donnell MP, Schad RF, Dmuchowski CF. Patient controlled analgesia versus PCA plus continuous infusion after hip replacement. *Ann Pharmacother* 1996; **30**: 224–7
Stahlgren L, Trierweiler M, Tommeraasen M, *et al.* Comparison of ketorolac and meperidine in patients with postoperative pain—impact in health care utilization. *Clin Ther* 1993; **15**: 571–81
Tsui SL, Chan CS, Chan AS, Wong SJ, Lam CS, Jones RD. Postoperative analgesia for oesophageal surgery: a comparison of three analgesic regimens. *Anaesth Intensive Care* 1991; **19**: 329–37
Tsui SL, Lo RJ, Tong WN, *et al.* A clinical audit for postoperative pain control on 1443 surgical patients. *Acta Anaesthesiol Sin* 1995; **33**: 137–48
Vijayan R. Subcutaneous morphine—a simple technique for postoperative analgesia. *Acute Pain* 1997; **1**: 21–6

Appendix III

References used to obtain incidences of moderate or greater pain—PCA

Albert JM, Talbott TM. PCA versus conventional intramuscular analgesia following colon surgery. *Dis Colon Rectum* 1988; **31**: 83–6
Atwell JR, Flanigan RC, Bennett RL, Allen DC, Lucas BA, McRoberts JW. The efficacy of patient controlled analgesia in patients recovering from flank incisions. *J Urol* 1984; **132**: 701–3
Badner NH, Doyle JA, Smith MH, Herrick IA. Effect of varying intravenous PCA dose and lockout interval while maintaining a constant hourly maximum dose. *J Clin Anesth* 1996; **8**: 382–5
Bahar M, Rosen M, Vickers MD. Self-administered nalbuphine, morphine and pethidine. *Anaesthesia* 1985; **40**: 529–32
Bennett RL, Batenhorst RL, Bivins BA, *et al.* PCA: a new concept of postoperative pain relief. *Ann Surg* 1982; **195**: 700–4
Bennett RL, Batenhorst RL, Graves DA, Foster TS, Griffen WO, Wright BD. Variation in postoperative analgesic requirements in the morbidly obese following gastric bypass surgery. *Pharmacotherapy* 1982; **2**: 50–3
Black AM, Goodman NW, Bullingham RE, Lloyd J. Intramuscular ketorolac and morphine during PCA after hysterectomy. *Eur J Anaesthesiol* 1990; **7**: 9–17
Blackburn A, Stevens JD, Wheatley RG, Madej TH, Hunter D. Balanced analgesia with intravenous kerorolac and PCA morphine following abdominal surgery. *J Clin Anaesth* 1995; **7**: 103–8
Bollish SJ, Collins CL, Kirking DM, Bartlett RH. Efficacy of patient controlled versus conventional analgesia for postoperative pain. *Clin Pharm* 1985; **4**: 48–52
Cepeda MS, Vargas L, Ortegan G, Samnchez MA, Carr DB. Comparative analgesic efficacy of patient controlled analgesia with ketorolac versus morphine after elective intra-abdominal operations. *Anesth Analg* 1995; **80**: 1150–3
Chauvin M, Hongnat JM, Mourgeon E, Lebrault C, Bellanfant F, Alfonsi P. Equivalence of postoperative analgesia with patient controlled intravenous or epidural alfentanil. *Anesth Analg* 1993; **76**: 1251–8
Coleman SA, Brooker-Milburn J. Audit of postoperative pain control. *Anaesthesia* 1996; **51**: 1093–6
Dahl JB, Daugaard JJ, Larsen HV, Nielsen TH, Kristoffersen E. Patient controlled analgesia: a controlled trial. *Acta Anaesthesiol Scand* 1987; **31**: 744–7
Dawson PJ, Libreri FC, Jones DJ, Libreri G, Borkstein AR, Royse CF. The efficacy of adding a continuous intravenous morphine infusion to patient controlled analgesia in abdominal surgery. *Anaesth Intensive Care* 1995; **23**: 453–8
Dingus DJ, Sherman JC, Rogers DA, DiPiro JT, May R, Bowden TA. Buprenorphine versus morphine for PCA after cholecystectomy. *Surg Gynecol Obstet* 1993; **177**: 1–6
Eisenach JC, Grice SC, Dewan DM. Patient controlled analgesia following cesarean section; a comparison with epidural and intramuscular narcotics. *Anesthesiology* 1988; **68**: 444–8
Etches RC, Warriner CB, Badner N, *et al.* Continuous intravenous administration of ketorolac reduces pain and morphine consumption after total hip and knee arthroplasty. *Anesth Analg* 1995; **81**: 1175–80
Gallion HH, Wermeling DP, Foster TS, VanNagell JR, Donaldson ES. PCA in gynaecologic oncology. *Gynecol Oncol* 1987; **27**: 247–52
George KA, Wright PM, Chisakuta A, *et al.* Thoracic epidural analgesia compared with patient controlled intravenous morphine after

upper abdominal surgery. *Acta Anaesthesiol Scand* 1994; **38**: 808–12

Gilliland HE, Prasad BK, Mirakhur RK, Fee JP. An investigation of the potential morphine sparing effect of midazolam. *Anaesthesia* 1996; **51**: 808–11

Hansen LE, Noyes MA, Lehman ME. Evaluation of PCA versus PCA plus continuous infusion in postoperative cancer patients. *J Pain Symptom Manage* 1991; **6**: 4–14

Harmer M, Slattery P, Rosen M, Vickers MD. Intramuscular on demand analgesia: double blind controlled trial of pethidine, buprenorphine, morphine and meptazinol. *Br J Anaesth* 1983; **286**: 680–2

Harrison DM, Sinatra R, Morgese L, Chung JH. Epidural narcotic and PCA for post-cesarean section pain relief. *Anesthesiology* 1988, **68**: 454–7

Jayr C, Beaussier M, Gustafsson Y, *et al.* Continuous epidual infusion of ropivacaine for postoperative analgesia after abdominal surgery. *Br J Anaesth* 1998; **81**: 887–92

Kenady DE, Wilson JF, Schwartz RW. Bannon CL. A randomised comparison of PCA versus standard analgesic requirements in patients undergoing cholecystetomy. *Surg Gynecol Obstet* 1992; **174**: 216–8

Kilbride MJ, Senagore AJ, Mazier WP, Ferguson C, Ufkes T. Epidural analgesia. *Surg Gynecol Obstet* 1992; **174**: 137–40

Klasen JA, Opitz SA, Melzer C, Thiel A, Hempelmann G. Intrarticular, epidural and intravenous analgesia after total knee arthoplasty. *Acta Anaesthesiol Scand* 1999; **43**: 1021–6

deKock MF, Pinchon GP, Scholtes JL. Intraoperative clonidine enhances postoperative morphine PCA. *Can J Anaesth* 1992; **39**: 537–44

van Lancker P, Mortier E, Pieters A, Rolly G. Evaluation of morphine for PCA with the infusorsystem after opiate free locoregional anesthesia for osteotomy of the foot. *Acta Anaesthesiol Belgica* 1995; **46**: 113–9

Lange MP, Dahn MS, Jacobs LA. PCA versus intermittent analgesia dosing. *Heart Lung* 1988; **17**: 495–8

Lehmann KA, Kratzenberg U, Schroeder-Bark B, Horrichs-Haermeyer G. Postoperative PCA with tramadol: analgesic efficacy and minimum effective concentrations. *Clin J Pain* 1990; **6**: 212–20

Lehmann KA, Ribbert N, Horrichs-Haermeyer G. Postoperative PCA with alfentanil: anlgesic efficacy and minimum effective concentrations. *J Pain Symptom Manage* 1990; **5**: 249–58

Lehmann KA, Gerhard A, Horrichs-Haermeyer G, Grond S, Zech D. Postoperative PCA with sufentanil: analgesic efficacy and minimum effective concentrations. *Acta Anaesthesiol Scand* 1991; **35**: 221–6

de Leon-Casasola O, Lema MJ, Karabella D, Harrison P. Postoperative myocardial ischaemia: epidural v intravenous PCA. *Reg Anesth* 1995; **20**: 105–12

Loper KA, Ready LB, Nessly M, Rapp SE. Epidural morphine provides greater pain relief than PCA intravenous morphine following cholecystectomy. *Anesth Analg* 1989; **69**: 826–8

Loper KA, Ready LB, Downey M, *et al.* Epidural and intravenous fentanyl infusions are clinically equivalent after knee surgery. *Anesth Analg* 1990; **70**: 72–5

Lopez-Olaondo L, Carrascosa F, Pueyo FJ, Monedero P, Busto N, Saez A. Combination of ondansteron and dexamethasone in the prophylaxis of postoperative nausea and vomiting. *Br J Anaesth* 1996; **76**: 835–40

McKenzie R, Rudy T, Ponter-Hammill M. Side effects of morphine PCA and meperidine PCA: a follow-up of 500 patients. *J Am Assoc Nurse Anesth* 1992; **60**: 282–7

van den Nieuwenhuyzen MC, Engbers FH, Burm AG, Vletter AA, van Kleef JW, Bovill JG. Computer controlled infusion of alfentanil versus patient controlled administration of morphine for postoperative analgesia: a double blind randomised trial. *Anesth Analg* 1995; **81**: 671–9

Notcutt WG, Morgan RJ. Introducing patient-controlled analgesia for postoperative pain control into a district general hospital. *Anaesthesia* 1990; **45**: 401–6

Owen H, Plummer JL, Armstrong I, Mather LE, Cousins MJ. Variables of PCA 1: bolus size. *Anaesthesia* 1989, **44**: 7–10

Owen H, Currie JC, Plummer JL. Variation in the blood concentration/analgesic response relationship during PCA with fentanyl. *Anaesth Intensive Care* 1991; **19**: 555–60

Parker RK, Holtmann B, White PF. PCA: does concurrent opioid infusion improve pain management after surgery. *JAMA* 1991; **266**: 1947–52

Persson K, Sjostrom S, Sigurdartdottir I. Patient controlled analgesia with codeine for postoperative pain relief in ten extensive metabolisers and one poor metaboliser of dextromethorphan. *Br J Clin Pharmacol* 1995; **39**: 182–6

Pryle BJ, Vanner RG, Enriquez N, Reynolds F. Can pre-emptive lumbar epidural blockade reduce postoperative pain following lower abdominal surgery. *Anaesthesia* 1993; **48**: 120–3

Pueyo FJ, Carrascosa F, Lopez L, Iribarren MJ, Garcia-Pedrajas F, Saez A. Combination of ondasetron and droperidol in the prophylaxis of postoperative nauseå and vomiting. *Anesth Analg* 1996; **83**: 117–22

Robinson SL, Rowbotham DJ, Mushambi M. Electronic and disposable PCA systems. *Anaesthesia* 1992; **47**: 161–3

Rosenberg PH, Heino A, Scheinin B. Comparison of IM analgesia, intercostal block, epidural morphine and on-demand intravenous fentanyl in the control of pain after upper abdominal surgery. *Acta Anaesthesiol Scand* 1984; **28**: 603–7

Russell AW, Owen H, Ilsley AH, Kluger MT, Plummer JL. Background infusion with patient controlled analgesia: effect on postoperative oxyhaemoghlobin saturation and pain control. *Anaesth Intensive Care* 1993; **21**: 174–9

Sands RP, de Leon-Casasola OA, Harrison P, Velagapudi S, Lema MJ. Randomised double blind comparison of epidural and intravenous fentanyl for postoperative pain. *Acute Pain* 1997; **1**: 7–14

Sawaki Y, Parker RK, White PF. Patient and nurse evaluation of PCA delivery systems for postoperative pain management. *J Pain Symptom Manage* 1992; **7**: 443–53

Schug SA, Fry RA. Continuous regional analgesia in comparison with intravenous opioid administration for routine postoperative pain control. *Anaesthesia* 1994; **49**: 528–32

Scott DA, Chamley DM, Mooney PH, Deam RK, Mark AH, Hagglof B. Epidural ropivacaine infusion for postoperative analgesia after major lower abdominal surgery—a dose finding study. *Anesth Analg* 1995; **81**: 982–6

Searle NR, Roy M, Bergeron G, *et al.* Hydromorphone PCA after coronary artery bypass surgery. *Can J Anaesth* 1994; **41**: 198–205

Sharma SK, Davies MW. Patient controlled analgesia with a mixture of morphine and droperidol. *Br J Anaesth* 1993; **71**: 435–6

Shipton EA, Beeton AG, Minkowitz HS. Introducing a PCA based Acute Pain relief service into southern Africa—the first 10 months. *SAMJ* 1993; **83**: 501–55

Sidebotham D, Dijkhuizen MR, Schug SA. The safety and utilization of patient controlled analgesia. *J Pain Symptom Manage* 1997; **14**: 202–9

Smythe M, Loughlin K, Schad RF, Lucarroti RL. PCA versus intramuscular analgesic therapy. *Am J Hosp Pharm* 1994; **51**: 1433–41

Stanley G, Appadu B, Mead M, Rowbotham DJ. Dose requirements,

efficacy and side effects of morphine and pethidine by patient controlled analgesia after gynaecological surgery. *Br J Anaesth* 1996; **76**: 484–6

Tamsen A, Hartvig P, Dahlstrom B, Lindstrom B, Holmdahl H. Patient controlled analgesic therapy in the early postoperative period. *Acta Anaesthesiol Scand* 1979; **23**: 462–70

Tamsen A, Hartvig P, Faherlund G, Dahlstrom B, Bondesson U. Patient controlled analgesic therapy: clinical experience. *Acta Anaesthesiol Scand* 1982; **74**: 157–60

Taylor NM, Hall GM, Salmon P. Patients' experiences of patient-controlled analgesia. *Anaesthesia* 1996; **51**: 525–8

Tsui SL, Lo RJ, Tong W, *et al.* A clinical audit for postoperative pain control on 1443 surgical patients. *Acta Anaesthesiol Sin* 1995; **33**: 137–48

Tsui SL, Tong WN, Irwin M *et al.* The efficacy, applicability and side effects of postoperative intravenous patient controlled morphine analgesia: an audit of 1233 Chinese patients. *Anaesth Intensive Care* 1996; **24**: 658–64

Tsui SL, Lee DK, Ng KF, Chan TY, Chan WS, Lo JW. Epidural infusion of bupivacaine plus fentanyl provides better postoperative analgesia than patient controlled analgesia with intravenous morphine after gynaecological laparotomy. *Anaesth Intensive Care* 1997; **25**: 476–81

Upton PM, Beeton AG, Minkowitz HS, Shipton EA. PCA: its South African debut in a provincial hospital. *SAMJ* 1992; **81**: 74–6

Watts RW, Fletcher IA, Kiroff GK, Weber C, Owen H, Plummer JL. The introduction of PCA into isolated rural hospital. *Aust NZ J Surg* 1995; **65**: 588–91

Wermeling DP, Greene SA, Boucher BA *et al.* Multicenter evaluation of PCA device for the treatment of postoperative pain. *Clin Pharm* 1992; **11**: 342–6

Wheatley RG, Madej TH, Jackson IJ, Hunter D. The first year's experience of an acute pain service. *Br J Anaesth* 1991; **67**: 353–9

White WD, Pearce DJ, Norman J. Postoperative analgesia: a comparison of intravenous on-demand fentanyl with epidural bupivacaine. *BMJ* 1979; **2**: 166–7

White PF. Subcutaneous PCA: an alternative to intravenous PCA for postoperative pain management. *Clin J Pain* 1990; **6**: 297–300

Wong LT, Koh LH, Kaur K, Boey SK. A two-year experience of an acute pain service in Singapore. *Singapore Med J* 1997; **38**: 209–13

Zacharias M, Pfeifer MV, Herbison P. Comparison of two methods of intravenous administration of morphine for postoperative pain relief. *Anaesth Intensive Care* 1990; **18**: 205–9

Appendix IV

References used to obtain incidences of moderate or greater pain—epidural

Asantila R, Rosenberg PH, Scheinin B. Comparison of different methods of postoperative analgesia after thoracotomy. *Acta Anaesthesiol Scand* 1986; **30**: 421–5

Bailey PW, Smith BE. Continuous epidural infusion of fentanyl for postoperative analgesia. *Anaesthesia* 1980; **35**: 1002–6

Baker MW, Tullos HS, Bryan WJ, Oxspring H. The use of epidural morphine in patients undergoing total knee arthroplasty. *J Arthroplasty* 1989; **4**: 157–9

Banning AM, Schmidt JF, Chraemmer-Jorgensen B, Risbo A. Comparison of oral controlled release morphine and epidural morphine in the management of postoperative pain. *Anesth Analg* 1986; **65**: 385–8

el-Baz N, Goldin M. Continuous epidural infusion of morphine for pain relief after cardiac operations. *J Thorac Cardiovasc Surg* 1987; **93**: 878–83

Bisgaard C, Mouridsen P, Dahl J. Continuous lumbar epidural bupivacaine plus morphine v. epidural morphine after major abdominal surgery. *Eur J Anaesthesiol* 1990; **7**: 219–25

Brodsky JB, Chaplan SR, Brose WG, Mark JB. Continuous epidural hydromorphone for postthoracotomy pain relief. *Ann Thor Surg* 1990; **50**: 888–93

Broekema AA, Gielein MJ, Hennis PJ. Postoperative analgesia with continuous epidural sufentanil and bupivacaine. *Anesth Analg* 1996; **82**: 754–9

Burstal R, Wegener F, Hayes C, Lantry G. Epidural analgesia: prospective audit of 1062 patients. *Anaesth Intensive Care* 1998; **26**: 165–72

Cahill J, Murphy D, O'Brien D, Mulhall J, Fitzpatrick G. Epidural buprenorphine for pain relief after major abdominal surgery. *Anaesthesia* 1983; **38**: 760–4

Callesen T, Scouenberg L, Nielsen D, Guldager H, Kehlet H. Combined epidural-spinal opioid free anaethesia and analgesia for hysterectomy. *Br J Anaesth* 1999; **82**: 885–88

Capdevila X, Barthelet Y, Biboulet P, Ryckwaert Y, Rubenovitch J, d'Athis F. Effects of perioperative analgesic technique on the surgical outcome and duration of rehabilitation after major knee surgery. *Anesthesiology* 1999; **91**: 8–15

Chaplan S, Duncan S, Brodsky J, Brose W. Morphine and hydromorphone epidural analgesia. *Anesthesiology* 1992; **77**: 1090–4

Chauvin M, Hongnat JM, Mourgeon E, Lebrault C, Bellenfant F, Alfonsi P. Equivalence of postoperative analgesia with patient controlled intravenous or epidural alfentanil. *Anesth Analg* 1993; **76**: 1251–8

Chisakuta AM, George KA, Hawthorne CT. Postoperative epidural infusion of a mixture of bupivacaine with fentanyl for upper abdominal surgery. *Anaesthesia* 1995; **50**: 72–5

Chrubasik J, Wiemers K. Continuous plus on demand epidural infusion of morphine for postoperative pain relief by means of a small externally worn infusion device. *Anesthesiology* 1985; **62**: 263–7

Coleman SA, Brooker-Milburn J. Audit of postoperative pain control. *Anaesthesia* 1996; **51**: 1093–6

Conacher I, Paes M, Jacobsen L, Phillips P, Heaviside D. Epidural analgesia following thoracic surgery. *Anaesthesia* 1983; **38**: 546–51

Cox CR, Serpell MG, Bannister J, Coventry DM, Williams DR. A comparison of epidural infusions of fentanyl or pethidine with bupivacaine in the management of postoperative pain. *Anaesthesia* 1996; **51**: 695–8

Cullen M, Staren E, El-Ganzouri, Logas W, Ivankovich A, Economou S. Continuous epidural infusion for analgesia after major abdominal operations. *Surgery* 1985; **98**: 718–26

Dahl JB, Hansen BL, Hjortso NC, Erichsen CJ, Moiniche S, Kehlet H. Influence of timing on the effect of continuous extradural analgesia with bupivacaine and morphine after major abdominal surgery. *Br J Anaesth* 1992; **69**: 4–8

Duncan LA, Fried MJ, Lee A, Wildsmith JA. Comparison of continuous and intermittent adminstration of extradural bupivacaine for analgesia after lower abdominal surgery. *Br J Anaesth* 1998; **80**: 7–10

Eisenach JC, Grice SC, Dewan DM. Patient controlled analgesia following cesarean section; a comparison with epidural and intramuscular narcotics. *Anesthesiology* 1988; **68**: 444–8

Etches RC, Sandler AN, Lawson SL. A comparison of the analgesic and respiratory effects of epidural nalbuphine or morphine in post-thoracotomy patients. *Anesthesiology* 1991; **75**: 9–14

Fromme GA, Steidl LJ, Danielson DR. Comparison of lumbar and

thoracic morphine for relief of postthoracotomy pain. *Anesth Analg* 1985; **64**: 454–5

George KA, Wright PM, Chisakuta A. Continuous epidural fentanyl for post-thoracotomy pain relief. *Anaesthesia* 1991; **46**: 732–6

George KA, Chisakuta AM, Gamble JA, Browne GA. Thoracic epidural infusion for postoperative pain relief following abdominal aortic surgery. *Anaesthesia* 1992; **47**: 388–94

George KA, Wright PM, Chisakuta AM, Rao NV. Thoracic epidural analgesia compared with patient controlled intravenous morphine after upper abdominal surgery. *Acta Anaesthesiol Scand* 1994; **38**: 808–12

Griffiths DP, Diamond AW, Cameron JD. Postoperative extradural analgesia following thoracic surgery: a feasibility study. *Br J Anaesth* 1975; **47**: 48–54

Gundersen RY, Andersen R, Narverud G. Postoperative pain relief with high dose epidural buprenorphine: a double blind study. *Acta Anaesthesiol Scand* 1986; **30**: 664–7

Hansdottir V, Bake B, Nordberg G. The analgesic efficacy and adverse effects of continuous epidural sufentanil and bupivacaine infusion after thoracotomy. *Anesth Analg* 1996; **83**: 394–400

Harbers JB, Hasenbos MA, Gort C, Folgering H, Dirksen R, Gielen MJ. Ventilatory function and continuous high thoracic epidural administration of bupivacaine with sufentanil intravenously or epidurally: a double blind comparison. *Reg Anesth* 1991; **16**: 65–71

Harrison DM, Sinatra R, Morgese L, Chung JH. Epidural narcotic and PCA for post-cesarean section pain relief. *Anesthesiology* 1988; **68**: 454–7

Hasenbos M, Van Egmond J, Gielen M, Crul JF. Postoperative analgesia by epidural versus intramuscular nicomorphine after thoracotomy. Part II. *Acta Anaesthesiol Scand* 1985; **29**: 577–82

Hasenbos M, van Egmond J, Gielen M, Crul JF. Postoperative analgesia by high thoracic epidural versus intramuscular nicomorphine after thoracotomy. *Acta Anaesthesiol Scand* 1987; **31**: 608–15

Hjortso NC, Neumann P, Frosig F, *et al.* A controlled study on the effect of epidural analgesia with local anaesthetics and morphine on morbidity after abdominal surgery. *Acta Anaesthesiol Scand* 1985; **29**: 790–6

Hjortso NC, Lund C, Mogensen T, Bigler D, Kehlet H. Epidural morphine improves pain relief and maintains sensory analgesia during continuous epidural bupivacaine after abdominal surgery. *Anesth Analg* 1986; **65**: 1033–6

Hobbs GJ, Roberts FL. Epidural infusion of bupivacaine and diamorphine for postoperative analgesia: use on general surgical wards. *Anaesthesia* 1992; **47**: 58–62

Holmdahl MH, Sjogren S, Strom G, Wright B. Clinical aspects of continuous epidural blockade for postoperative pain relief. *Upsala Med J* 1972; **77**: 47–56

Hurford WE, Dutton RP, Alfille PH, Clement D, Wilson RS. Comparison of thoracic and lumbar epidural infusions of bupivacaine and fentanyl for postthoracotomy analgesia. *J Cardiothorac Vasc Anaesth* 1993; **7**: 521–5

Jayr C, Thomas H, Rey A, Farhat F, Lasser P, Bourgain JL. Postoperative pulmonary complications: epidural analgesia using bupivacaine and opioids v. parenteral opioids. *Anesthesiology* 1993; **78**: 666–76

Jayr C, Beaussier M, Gustafsson Y, *et al.* Continuous epidual infusion of ropivacaine for postoperative analgesia after abdominal surgery. *Br J Anaesth* 1998; **81**: 887–92

Kilbride MJ, Senagore AJ, Mazier WP, Ferguson C, Ufkes T. Epidural analgesia. *Surg Gynecol Obstet* 1992; **174**: 137–40

Klasen JA, Opitz SA, Melzer C, Thiel A, Hempelmann G. Intrarticular, epidural and intravenous analgesia after total knee arthroplasty. *Acta Anaesthesiol Scand* 1999; **43**: 1021–6

de Kock M, Gautier P, Pavlopolou A, Jonniaux M, Lavand'homme P. Epidural clonidine or bupivacaine as the sole analgesic agent during and after abdominal clonidine. *Anesthesiology* 1999; **90**: 1354–62

Larsen VH, Iversen AD, Christensen P, Andersen PK. Postoperative pain treatments after upper abdominal surgery with epidural morphine at thoracic or lumbar level. *Acta Anaesthesiol Scand* 1985; **29**: 566–71

Laveaux MM, Hasenbos MA, Harbers JB, Liem T. Thoracic epidural bupivacaine plus sufentanil: high concentration/low volume versus low concentration/high volume. *Reg Anaesth* 1993; **18**: 39–43

Lee A, Simpson D, Whifield A, Scott D. Postoperative analgesia by continuous extradural infusion of bupivacaine and diamorphine. *Br J Anaesth* 1988; **60**: 845–50

Leith S, Wheatley RG, Jackson IJ, Madej TH, Hunter D. Extradural infusion analgesia for postoperative pain relief. *Br J Anaesth* 1994; **73**: 552–8

de Leon-Casasola OA, Lema MJ, Karabella D, Harrison P. Postoperative myocardial ischaemia: epidural versus intravenous PCA. *Reg Anesth* 1995; **20**: 105–12

Logas WG, el-Baz N, el-Ganzouri A, *et al.* Continuous thoracic epidural analgesia for postoperative pain relief following thoracotomy. *Anesthesiology* 1987; **67**: 787–91

Loper KA, Ready LB. Epidural morphine after anterior cruciate ligament repair: a comparison with patient-controlled intravenous morphine. *Anesth Analg* 1989; **68**: 350–2

Loper KA, Ready LB, Nessly M, Rapp SE. Epidural morphine provides greater pain relief than PCA intravenous following cholecystectomy. *Anesth Analg* 1989; **69**: 826–8

Loper KA, Ready LB, Downey M, *et al.* Epidural and intravenous fentanyl infusions are clinically equivalent after knee surgery. *Anesth Analg* 1990; **70**: 72–5

Lubenow TR, Faber LP, McCarthy RJ, Hopkins EM, Warren WH, Ivankovitch AD. Post-thoracotomy pain management using continuous epidural analgesia in 1324 patients. *Ann Thorac Surg* 1994; **58**: 924–30

Lubenow TR, Tanck EN, Hopkins EM, *et al.* Comparison of patient assisted epidural analgesia with continuous epidural analgesia for postoperative patients. *Reg Anesthesia* 1994; **19**: 206–11

Magora F, Olshwang D, Eimerl D, *et al.* Observations on extradural morphine analgesia in various pain conditions. *Br J Anaesth* 1980; **52**: 247–52

Mahoney OM, Noble PC, Davidson J, Tullos HS. The effect of continuous epidural analgesia on postoperative pain, rehabilitation and duration of hospitalisation in total knee arthroplasty. *Clin Orthopaed Related Res* 1990; **260**: 30–7

Marlowe S, Engstrom R, White PF. Epidural PCA: an alternative to continuous epidural infusions. *Pain* 1989; **37**: 97–101

Mehnert JH, Dupont TJ, Rose DH. Intermittent epidural morphine instillation for control of postoperative pain. *Am J Surg* 1983; **146**: 145–51

Mehta Y, Juneja R, Madhok H, Trehan N. Lumbar versus thoracic epidural buprenorphine for postoperative analgesia following coronary artery bypass graft surgery. *Acta Anaesthesiol Scand* 1999; **43**: 388–93

Mogensen T, Hjortso NC, Bigler D, Lund C, Kehlet H. Unpredictability of regression of analgesia during the continuous postoperative extradural infusion of bupivacaine. *Br J Anaesth* 1988; **60**: 515–9

Mourisse J, Hasenbos MA, Gielen MJ, Moll JE, Cromheecke GJ. Epidural bupivacaine, sufentanil or the combination for post-thoracotomy pain. *Acta Anaesthesiol Scand* 1992; **36**: 70–4

Muldoon T, Milligan K, Quinn P, Connolly DC, Nilsson K. Comparison

between extradural infusion of ropivacaine or bupivacaine for the prevention of postoperative pain after total knee replacement. *Br J Anaesth* 1998; **80**: 680–1

Nolan J, Dow A, Parr M, *et al.* Patient controlled epidural analgesia following post-traumatic pelvic reconstruction. *Anaesthesia* 1992; **47**: 1037–41

Owen H, Kluger MT, Ilsley AH, Baldwin AM, Fronsko RR, Plummer JL. The effect of fentanyl administered epidurally by patient controlled analgesia, continuous infusion, or a combined technique of oxyhaemoglobin saturation after abdominal surgery. *Anaesthesia* 1993; **48**: 20–5

Raj PP, Knarr DC, Vigdorth E, *et al.* Comparison of continuous infusion of a local anaesthetic and administration of systemic narcotics in the management of pain after total knee replacement surgery. *Anesth Analg* 1987; **66**: 401–6

Rawal N, Sjostrand U, Dahlstrom B. Postoperative pain relief by epidural morphine. *Anesth Analg* 1981; **60**: 726–31

Rawal N, Sjostrand U, Christoffersson E, Dahlstrom B, Arvill A, Rydman H. Comparison of intramuscular and epidural morphine for postoperative analgesia in the grossly obese. *Anesth Analg* 1984; **63**: 583–92

Rawal N, Schott U, Dahlstrom B, *et al.* Influence of naloxone infusion of analgesia and respiratory depression following epidural morphine. *Anesthesiology* 1986; **64**: 194–201

Renaud B, Brichant JF, Clergue F, Chauvin M, Levron JC, Viars P. Ventilatory effects of continuous epidural infusion of fentanyl. *Anesth Analg* 1988; **67**: 971–5

Rosenberg PH, Heino A, Scheinin B. Comparison of intramuscular analgesia, intercostal block, epidural morphine and on-demand intravenous fentanyl in the control of pain after upper abdominal surgery. *Acta Anaesthesiol Scand* 1984; **28**: 603–7

Ross R, Clarke J, Armitage E. Postoperative pain prevention by continuous epidural infusion. *Anaesthesia* 1980; **35**: 663–8

Rosseel PM, van den Broek WG, Boer EC, Prakash O. Epidural sufentanil for intra and postoperative analgesia in thoracic surgery: a comparative study with intravenous sufentanil. *Acta Anaesthesiol Scand* 1988; **32**: 193–8

Rygnestad T, Borchgrevink P, Eide E. Postoperative epidural infusion of morphine and bupivacaine is safe on surgical wards. *Acta Anaesthesiol Scand* 1997; **41**: 868–79

Rygnestad T, Zahlsen K, Bergslien O, *et al.* Focus on mobilisation after lower abdominal surgery. A double blind randomised comparison of epidural bupivacaine with morphine versus lidocaine with morphine postoperative analgesia. *Acta Anaesthesiol Scand* 1999; **43**: 380–7

Salomaki TE, Laitinen JO, Nuutinen LS. A randomized double blind comparison of epidural versus intravenous fentanyl infusion for analgesia after thoracotomy. *Anesthesiology* 1991; **75**: 790–5

Salomaki TE, Laitinen JO, Vainionpaa V, Nuutinen LS. 0.1% bupivacaine does not reduce the requirement for epidural fentanyl infusion after major abdominal surgery. *Reg Anesth* 1995; **20**: 435–43

Salomaki T, Kokki H, Turunen M. Havukainen U, Nuutinen L. Introducing epidural fentanyl for on-ward pain relief after major surgery. *Acta Anaesthesiol Scand* 1996; **40**: 704–9

Sandler AN, Stringer D, Panos L, *et al.* A randomized double-blind comparison of lumbar epidural and iv fentanyl infusions for post-thoracotomy pain relief. *Anesthesiology* 1992; **77**: 626–34

Sands RP, de Leon-Casasola OA, Harrison P, Velagapudi S, Lema MJ. Randomised double blind comparison of epidural and intravenous fentanyl for postoperative pain. *Acute Pain* 1997; **1**: 7–14

Sawchuck CW, Ong B, Unruh HW, Horan TA, Greengrass R. Thoracic versus lumbar epidural fentanyl for post-thoracotomy pain. *Ann Thorac Surg* 1993; **55**: 1472–6

Schug SA, Fry RA. Continuous regional analgesia in comparison with intravenous opioid administration for routine postoperative pain control. *Anaesthesia* 1994; **49**: 528–32

Schultz A-M, Werba A, Ulbing S, Gollmann G, Lehofer F. Perioperative thoracic epidural analgesia for thoracotomy. *Eur J Anaesthesiol* 1997; **14**: 600–3

Scheinin B, Asantila R, Orko R. The effect of bupivacaine and morphine on pain and bowel function after colonic surgery. *Acta Anaesthesiol Scand* 1987; **31**: 161–4

Schwartz BR, Gregg RV, Kessler DL, Bracken RB. Continuous postoperative epidural analgesia in management of postoperative surgical pain. *Urology* 1989; **34**: 349–52

Scott DA, Beilby DS, McClymont C. Postoperative analgesia using epidural infusions of fentanyl with bupivacaine. *Anesthesiology* 1995; **82**: 727–37

Scott DA, Chamley DM, Mooney PH, Deam R, Mark AH, Hagglof B. Epidural ropivacaine infusion for postoperative analgesia after major lower abdominal surgery—a dose finding study. *Anesth Analg* 1995; **81**: 982–6

Scott NB, James K, Murphy M, Kehlet H. Continuous thoracic epidural analgesia versus combined spinal/thoracic epidural analgesia on pain, pulmonary function and metabolic response following colonic surgery. *Acta Anaesthesiol Scand* 1996; **40**: 691–6

Shir Y, Raja SN, Frank SM. The effect of epidural versus general anesthesia on postoperative pain and analgesic requirements in patients undergoing radical prostatectomy. *Anesthesiology* 1994; **80**: 49–56

Sidebotham DA, Russell K, Dijkhuizen M, Tester P, Schug SA. Low dose fentanyl improves continuous bupivacaine epidural analgesia following orthopaedic, urological or general surgery. *Acute Pain* 1997; **1**: 27–32

Singh H, Bossard R, White P, Yeatts R. Effects of ketorolac v. bupivacaine coadministration during patient controlled hydromorphone epidural analgesia after thoracotomy procedures. *Anesth Analg* 1997; **84**: 564–9

Sjostrom S, Hartvig D, Tamsen A. Patient controlled analgesia with extradural morphine or pethidine. *Br J Anaesth* 1988; **60**: 358–66

Snijdelaar DG, Hasenbos MA, van Egmond J, Wolff AP, Liem TH. High thoracic epidural sufentanil with bupivacaine: continuous infusion of high volume versus low volume. *Anesth Analg* 1994; **78**: 490–4

Stenseth R, Sellevold O, Breivik H. Epidural morphine for postoperative pain: experience with 1085 patients. *Acta Anaesthesiol Scand* 1985; **29**: 148–56

Stuart-Taylor ME, Billingham IS, Barrett RF, Church JJ. Extradural diamorphine for postoperative analgesia: audit of a nurse-administered service to 800 patients in a district general hospital. *Br J Anaesth* 1992; **68**: 429–32

Torda TA, Pybus DA. Clinical experience with epidural morphine. *Anaesth Intensive Care* 1981; **9**: 129–34

Tsui SL, Chan CS, Chan AS, Wong SJ, Lam CS, Jones RD. Postoperative analgesia for oesophageal surgery: a comparison of three analgesic regimens. *Anaesth Intensive Care* 1991; **19**: 329–37

Tsui SL, Lo RJ, Tong W, *et al.* A clinical audit for postoperative pain control on 1443 surgical patients. *Acta Anaesthesiol Sin* 1995; **33**: 137–48

Tsui SL, Lee DK, Ng KF, Chan TY, Chan WS, Lo JW. Epidural infusion of bupivacaine plus fentanyl provides better postoperative analgesia than patient controlled analgesia with intravenous morphine after gynaecological laparotomy. *Anaesth Intensive Care* 1997; **25**: 476–81

Vandermeersch E. Epidural PCA with bupivacaine and sufentanil. *Acta Anaesthesiol Belgica* 1992; **43**: 71–4

Wheatley RG, Madej TH, Jackson IJ, Hunter D. The first year's experience of an Acute Pain service. *Br J Anaesth* 1991; **67**: 353–9

White WD, Pearce DJ, Norman J. Postoperative analgesia: a comparison of intravenous on-demand fentanyl with epidural bupivacaine. *BMJ* 1979; **2**: 166–7

Wong LT, Koh LH, Kaur K, Boey SK. A two-year experience of an Acute Pain service in Singapore. *Singapore Med J* 1997; **38**: 209–13

Writer WD, Hurtig JB, Evans D, Needs RE, Hope CE, Forrest JB. Epidural morphine prophylaxis of postoperative pain: report of a double blind multicentre study. *Can Anaesth Soc J* 1985; **32**: 330–8

Appendix V

References used to calculate incidence of premature catheter dislodgement

Badner NH, Reimer EJ, Komar WE, Moote CA. Low dose bupivaciane does not improve postoperative epidural fentanyl analgesia in orthopaedic patients. *Anesth Analg* 1991; **72**: 337–41

Badner NH, Komar WE. Bupivacaine 0.1% does not improve postoperative epidural fentanyl analgesia after abdominal or thoracic surgery. *Can J Anaesth* 1992; **39**: 330–6

Baron CM, Kowalski SE, Greengrass R, Horan TA, Unruh HW, Baron CL. Epinephrine decreases postoperative requirements for continuous thoracic epidural fentanyl infusions. *Anesth Analg* 1996; **82**: 760–5

Bredtmann RD, Herden HN, Teichmann W, *et al.* Epidural analgesia in colonic surgery: results of a randomised prospective study. *Br J Surg* 1990; **77**: 638–42

Brodsky JB, Chaplan SR, Brose WG, Mark JB. Continuous epidural hydromorphone for postthoracotomy pain relief. *Ann Thorac Surg* 1990; **50**: 888–93

Broekema AA, Gielein MJ, Hennis PJ. Postoperative analgesia with continuous epidural sufentanil and bupivacaine. *Anesth Analg* 1996; **82**: 754–9

Burstal R, Wegener F, Hayes C, Lantry G. Epidural analgesia: prospective audit of 1062 patients. *Anaesth Intensive Care* 1998; **26**: 165–72

Dahl JB, Hansen BL, Hjortso NC, Erichsen CJ, Moiniche S, Kehlet H. Influence of timing on the effect of continuous extradural analgesia with bupivacaine and morphine after major abdominal surgery. *Br J Anaesth* 1992; **69**: 4–8

Etches RC, Gammer T-L, Cornish R. Patient controlled epidural analgesia after thoracotomy: a comparison of meperidine with and wihout bupivacaine. *Anesth Analg* 1996; **83**: 81–6

Grant G, Boyd A, Zakowski M, *et al.* Thoracic versus lumbar administration of epidural morphine for postoperative analgesia after thoracotomy. *Reg Anesth* 1993; **18**: 351–5

Griffiths DP, Diamond AW, Cameron JD. Postoperative extradural analgesia following thoracic surgery: a feasibility study. *Br J Anaesth* 1975; **47**: 48–54

Ilahi OA, Davidson JP, Tullos HS. Continuous epidural analgesia using fentanyl and bupivacaine after total knee arthroplasty. *Clin Orthop Related Res* 1994; **299**: 44–52

Jayr C, Beaussier M, Gustafsson Y, *et al.* Continuous epidual infusion of ropivacaine for postoperative analgesia after abdominal surgery. *Br J Anaesth* 1998; **81**: 887–92

Johnson RG, Miller M, Murphy M. Intraspinal narcotic analgesia: a comparison of two methods of postoperative pain relief. *Spine* 1989; **14**: 363–6

Lee A, Simpson D, Whifield A, Scott DB. Postoperative analgesia by continuous extradural infusion of bupivacaine and diamorphine. *Br J Anaesth* 1988; **60**: 845–50

de Leon-Casasola OA, Parker B, Lema M, Harrison P, Massey J. Postoperative epidural bupivacaine–morphine therapy. *Anesthesiology* 1994; **81**: 368–75

Liu SS, Allen HW, Olsson GL. Patient controlled epidural analgesia with bupivacaine and fentanyl on hospital wards. *Anesthesiology* 1998; **88**: 688–95

Lubenow TR, Faber LP, McCarthy RJ, Hopkins EM, Warren WH, Ivankovitch AD. Post-thoracotomy pain management using continuous epidural analgesia in 1324 patients. *Ann Thorac Surg* 1994; **58**: 924–30

Mahoney OM, Noble PC, Davidson J, Tillos HS. The effect of continuous epidural analgesia on postoperative pain, rehabilitation and duration of hospitalisation in total knee arthroplasty. *Clin Orthop Related Res* 1990; **260**: 30–7

Mehnert JH, Dupont TJ, Rose DH. Intermittent epidural morphine instillation for control of postoperative pain. *Am J Surg* 1983; **146**: 145–51

Melendez JA, Cirella VN, Delphin ES. Lumbar epidural fentanyl analgesia after thoracic surgery. *J Cardiothor Anesth* 1989; **3**: 150–3

Paech MJ, Pavy TJ, Evans SF. Single-dose prophylaxis for postoperative nausea and vomiting after major abdominal surgery: ondanseteron versus droperidol. *Anaesth Intensive Care* 1995; **23**: 548–54

Paech MJ, Pavy TJ, Orlikowski CE, Lim W, Evans SF. Postoperative epidural infusion: a randomised double blind dose finding trial of clonidine in combination with bupivacaine and fentanyl. *Anesth Analg* 1997; **84**: 1323–8

Rapp SE, Ready LB, Greer BE. Postoperative pain management in gynecologic oncology patients utilizing epidural opiate analgesia and PCA. *Gynecol Oncol* 1989; **35**: 341–4

Ready LB, Loper KA, Nessly M, Wild L. Postoperative epidural morphine is safe on surgical wards. *Anesthesiology* 1991; **75**: 452–6

Salomaki TE, Kokki H, Turunen M, Havukainen U, Nuutinen LS. Introducing epidural fentanyl for on-ward pain relief after major surgery. *Acta Anaesthesiol Scand* 1996; **40**: 704–9

Sawchuck CW, Ong B, Unruh HW, Horan TA, Greengrass R. Thoracic versus lumbar epidural fentanyl for post-thoracotomy pain. *Ann Thorac Surg* 1993; **55**: 1472–6

Schug SA, Fry RA. Continuous regional analgesia in comparison with intravenous opioid administration for routine postoperative pain control. *Anaesthesia* 1994; **49**: 528–34

Scott DA, Beilby DS, McClymont C. Postoperative analgesia using epidural infusions of fentanyl with bupivacaine. *Anesthesiology* 1995; **82**: 727–37

Tsui SL, Lee DK, Ng KF, Chan TY, Chan WS, Lo JW. Epidural infusion of bupivacaine plus fentanyl provides better postoperative analgesia than patient controlled analgesia with intravenous morphine after gynaecological laparotomy. *Anaesth Intensive Care* 1997; **25**: 476–81

Welch DB, Hrynaszkiewicz A. Post-operative analgesia using epidural methadone: administration by the lumbar route for thoracic pain relief. *Anaesthesia* 1981; **36**: 1051–4

Wong LT, Koh LH, Kaur K, Boey SK. A two-year experience of an Acute Pain service in Singapore. *Singapore Med J* 1997, **38**: 209–13

References

1 Ready B, Oden R Chadwick H, *et al.* Development of an anesthesiology-based postoperative pain management service. *Anesthesiology* 1988; **68**: 100–6

2 Maier C, Kibbel K, Mercker S, Wulf H. Postoperative pain therapy at general nursing stations. An analysis of eight years experience at an anaesthesiological acute pain service. *Anaesthesist* 1994; **43**: 385–97

3 Commission on the Provision of Surgical Services. *Pain After Surgery*. Royal Colleges of Surgeons and Anaesthesists, London, 1990

4 Agency for Health Care Policy and Research. *Clinical Practice Guideline. Acute Pain Management: Operative or Medical Procedures of Trauma*. AHCPR, Rockville, 1992

5 Ready LB, Ashburn M, Caplan RA, *et al.* Practice guidelines for acute pain management in the peri-operative setting: a report of the American Society of Anesthesiologists task force on pain managenment. *Anesthesiology* 1995; **82**: 1071–81

6 Clinical Standards Advisory Group. *Services for Patients with Pain*. Department of Health, London, 1999

7 American Society of Anesthesiologists. *Practice Guidelines for the Management of Acute Pain in the Perioperative Setting*. ASA, 1995

8 Audit Commission. *Anaesthesia Under Examination*. Audit Commission, London, 1997

9 Rawal N, Allvin R. Epidural and intrathecal opioids for postoperative pain management in Europe: a 17 nation questionnaire study of selected hospitals. *Acta Anaesthesiol Scand* 1996; **40**: 1119–26

10 Armitage P, Berry G. *Statistical Methods in Medical Research*, 3rd Edn. Oxford: Blackwell, 1994

11 Marquardt HM, Razis PA. Prepacked take-home analgesia for day case surgery. *Br J Nursing* 1994; **5**: 114–8

12 Loan WB, Dundee JW. The value of the study of postoperative pain in the assessemnt of analgesics. *Br J Anaesth* 1967; **39**: 745–50

13 Thompson SG. Why sources of heterogeneity in meta-analysis should be investigated. *BMJ* 1994; **309**: 1351–5

14 Moriarty A, Mollenbrock G, Johnstone B, Potter GE. A ward-based, nurse managed, acute pain service in a district general hospital. *Today's Anaesthetist* 1993; **8**: 92–4

15 Liu W, Aitkenhead A. Comparison of contemporaneous and retrospective assessment of postoperative pain using the visual analogue scale. *Br J Anaesth* 1991; **67**: 768–71

16 Collins SL, Moore RA, McQuay HJ. The visual analogue pain intensity scale: what is moderate pain in millimetres? *Pain* 1997; **72**: 95–7

17 Schug SA, Fry RA. Continuous regional analgesia in comparison with intravenous opioid administration for routine postoperative pain control. *Anaesthesia* 1994; **49**: 528–32

18 Sidebotham DA, Russell K, Dijkhuizen MR, Tester P, Schug SA. Low dose fentanyl improves continuous bupivacaine epidural analgesia following orthopaedic, urological or general surgery. *Acute Pain* 1997; **1**: 27–32

19 Rygnestad T, Zahlsen K, Bergslien O, *et al.* Focus on mobilisation after lower abdominal surgery. A double blind randomised comparison of epidural bupivacaine with morphine versus lidocaine with morphine for postoperative analgesia. *Acta Anaesthesiol Scand* 1999; **43**: 380–387

20 de Leon-Casasola OA, Parker B, Lema MJ, Harrison P, Massey J. Postoperative epidural bupivacaine-morphine. Experience with 4,227 surgical cancer patients. *Anesthesiology* 1994; **81**: 308–15

21 Benhamou D. Measurement of postoperative pain. *Ann Fr Anaesth Reanimation* 1998; **17**: 555–71

22 Rawal N, Sjostrand U, Christoffersson E, Dahlstrom B, Arvill A, Rydman H. Comparison of intramuscular and epidural morphine for postoperative analgesia in the grossly obese. *Anesth Analg* 1984; **63**: 583–92

23 Gould TH, Crosby DL, Harmer M, *et al.* Policy for controlling pain after surgery: effect of sequential changes in management. *BMJ* 1992; **305**: 1187–93

24 Scott DA, Chamley DM, Mooney PH, Deam RK, Mark AH, Hagglof B. Epidural ropivacaine infusion for postoperative analgesia after major lower abdominal surgery—a dose finding study. *Anesth Analg* 1995; **81**: 982–98

25 Stenseth R, Sellevold O, Breivik H. Epidural morphine for postoperative pain: experience with 1085 patients. *Acta Anaesthesiol Scand* 1985; **29**: 148–56

26 Wheatley RG, Madej TH, Jackson IJ, Hunter D. The first year's experience of an Acute *Pain* service. *Br J Anaesth* 1991; **67**: 353–9

27 DonovanB. Patient attitudes to postoperative pain relief. *Anaesth Intensive Care* 1983; **11**: 125–8

28 Ferrante F, Ostheimer G, Covino B, eds. *Patient Controlled Analgesia*. Oxford: Blackwell Scientific, 1990