

Does an Acute Pain Service Improve Postoperative Outcome?

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Pain relief after surgical procedures continues to be a major medical challenge. Alleviation of pain has been given a high priority by the medical profession and the health authorities. Improvement in perioperative analgesia not only is desirable for humanitarian reasons, but is also essential for its potential to reduce postoperative morbidity (1–4) and mortality (2).

Inadequacies in postoperative pain relief have been evident for decades (5,6). The importance of establishing an organization for the management of postoperative pain relief, with special attention to a team approach, was proposed more than 40 yr ago (7). Although several editorials (8–10) from 1976 to 1980 again advocated the introduction of an analgesia team to supervise and administer pain relief and to take responsibility for teaching and training in postoperative pain management, almost a decade passed before a specialized in-hospital postoperative pain service emerged. Thus, in 1985 the first acute pain services (APSs) were introduced in the United States (11,12) and in Germany (13). Immediate and sustained formal support and authoritative recommendations from various medical and health care organizations promoted a widespread introduction of APSs (14–22). One document explicitly stated “that this service should be introduced in all major hospitals performing surgery in the UK” (15); this is in agreement with recommendations from the Agency for Health Care Policy and Research (United States) and the National Health and Medical Research Council (Australia), which state that all major acute care centers should have an APS (14,18).

Furthermore, provision of an APS is presently a prerequisite for accreditation for training by the Royal

College of Anaesthetists (23) and the Australian and New Zealand College of Anaesthetists. A Canadian survey from 1991, including 47 university-affiliated teaching hospitals, showed that 25 hospitals (53%) operated an APS and that an additional 17 (35%) were attempting to organize one (24) (Table 1). A survey in Australia and New Zealand in 1992–1993 from 111 larger institutions showed that 37 (33%) had an APS and 58 (53%) would have liked to or had plans to implement the service (25). Repeated surveys in 1994 and 1996 from New Zealand indicated in 22 larger institutions an increase from 12 to 17 APSs (29). In a European survey from 1993, including 105 representative hospitals from 17 countries, 34% of the hospitals had a formal APS (26). Forty-two percent to 73% of US hospitals, depending on size and academic affiliation, had an APS in 1995 (31,32). In the United Kingdom, the number of hospitals providing APSs increased from 3% in 1990 to 43% in 1994 (27,28,36), to 47% in 1996 (37), and to 49% in 1999 (35). In a recent survey from Germany, 36% of hospitals operated an APS, but the quality of criteria for the service was very variable (34).

The introduction of APSs has led to an increase in the use of specialized pain relief methods, such as patient-controlled analgesia (PCA) and epidural infusions of local anesthetic/opioid mixtures, in surgical wards. Implementation of these methods may represent real advances in improving patient well-being and in reducing postoperative morbidity (38).

However, a pertinent question is whether the extensive resources allocated to these commitments have been successful and cost-effective. The objective of this study, therefore, was to critically review the literature on APSs regarding outcome: pain relief, side effects of the postoperative pain treatment, patient satisfaction, therapy-related adverse events, morbidity, hospital stay, and cost issues.

Literature Search

Literature was identified by a MEDLINE search from March 1966 to February 2001. The reference lists from

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Table 1. National Surveys of the Prevalence of Acute Pain Services (APSs)

First author	Region/country	Survey year	Institutions	Prevalence ^a
Zimmerman (24)	Canada	1991	University-affiliated	25/47 (53%)
Goucke (25)	Australia, New Zealand	1992/1993	Larger hospitals	37/111 (33%)
Rawal (26)	Europe	1993	All	37/107 (34%)
Davies (27)	UK	1994	University-affiliated	77/221 (35%)
Windsor (28)	UK	1994 ^b	All	151/354 (43%)
		1990		[10/358 (3%)]
Merry (29)	New Zealand	1994	All	12/62 (19%)
Merry (29)	New Zealand	1996	All	17/22 ^c
Harmer (30)	UK	1995 ^d	University-affiliated	97/221 (44%)
Ready ^e (31)	US	1995	>100 beds	236/324 (73%)
Warfield (32)	US	1995	All	126/300 (42%)
Neugebauer (33)	Germany	1997	All	390/1000 (39%)
Stamer (34)	Germany	1999	All	161/446 (36%)
O'Higgins (35)	UK	2000 ^d	University-affiliated	>49% ^f

^a Formal APS = provision of staff and funding.

^b Survey was conducted in 1994 and contained a retrospective analysis of 1990 data.

^c This part of the survey included only 22 publicly funded Crown Health Enterprises with ≥ 150 beds.

^d Year of survey not stated.

^e Letter.

^f A total of 118 of 240 Anaesthetic College tutors confirmed the presence of an acute pain team to review epidural analgesia on the wards.

identified articles and from relevant textbooks were then manually searched for additional papers. One-hundred-fifty-four papers were retrieved and systematically evaluated by two of the authors (MUW, PR-N) (Fig. 1). Fifty-eight were classified as expert opinions (editorials or personal experience), 48 as audits, 18 as general reviews (pain, organization, and pain-relief methods), 17 as surveys (regional, national, and international), and 13 as clinical trials.

Objectives and Organization of an APS

A formal APS is an organization dedicated to the management of acute pain in surgical patients, parturients, or other patients with acute pain (11,14,15,20). The APS has the responsibility for the day-to-day management of postoperative pain and obstetric pain and should provide an organizational framework for an appropriate level of care and monitoring adjusted to the clinical condition of the patient and the technique used (15). The APS has an important role to ensure the safety of the techniques (39-41). Establishment of programs for the identification and management of complications by in-service training for medical and nursing staff involved in the management of postoperative pain is important (15,42). The APS is committed to audits and clinical research of the efficacy and outcomes of existing and new methods of treatment (15,16,18,43,44).

Recommendations for the structure of the APS were originally a multidisciplinary approach that used medical, nursing, pharmaceutical, and psychological expertise (11,15,20). In 73 of the reviewed articles relating to organizational aspects of the APS, 15 articles reported a multidisciplinary approach (physician,

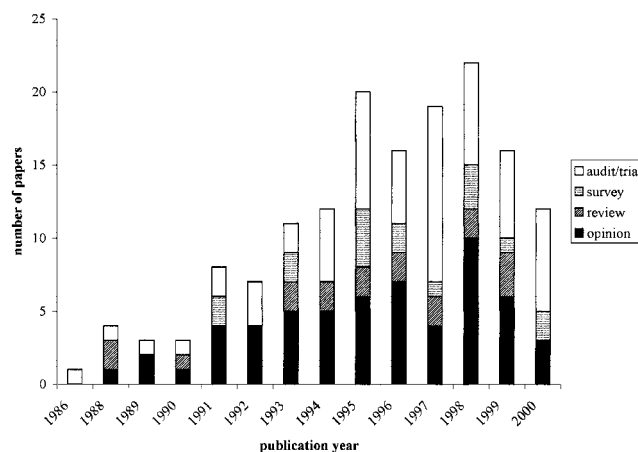


Figure 1. Number of articles ($n = 154$) and publication year: audit/trial (40%), survey (11%), review (12%), and opinion (38%).

nurse, physiotherapist, pharmacist, or psychologist), whereas in 56, the service was strictly physician based and in 17, strictly nurse based. Twenty-four-hour coverage has been recommended (11,20,45), but in a Canadian survey, only three quarters of the services provided this level of coverage (24). It has automatically been assumed that the APS should be under anaesthesiological auspices (11,15,31), but services managed primarily by ward surgeons have been reported (33,46).

Outcome Data

The 44 audits and 4 clinical trials containing outcome data included 84,097 postoperative patients (Table 2). Data were corrected for apparent duplicate publication. Two audit articles reported 22% of the patients (12,53).

Table 2. Audits and Trials in an Acute Pain Service (APS) Setting

First author	Year	Study design	n	Comments
Audits				
Maier (41)	1986	Retrospective	286	Initial clinical guidelines on APS implementation
Ready (11)	1988	Retrospective	820	Hallmark paper on APS
Petrakis (12)	1989	Retrospective	10,033	Preliminary experiences with an APS established in 1985
Kuhn (47)	1990	Prospective	101	Perceptions of pain relief
Cartwright (48)	1991	Retrospective	1,600	Audit for first 1600 patients
Wheatley (49)	1991	Prospective	660	1.2% serious complications
Gould (50)	1992	Prospective sequential	2,035	5-stage sequential changes in management
Stuart-Taylor (51)	1992	Retrospective	800	Epidural opioid-based analgesia respiratory depression 0.9%
Shipton (52)	1993	Retrospective	700	Implementation of PCA
Schug (39)	1993	Retrospective	3,016	Safety assessments
Ready (53)	1993	Retrospective	8,500	Organizational aspects
Blanco (54)	1994	Retrospective	1,214	Preliminary experiences with an APS
Maier (13)	1994	Retrospective	1,947	8 yr experience
Vijayan (55)	1994	Prospective	183	Quality assessment before an APS
Gould (56)	1994	Prospective		203 house officers/54 replied
Leeson-Payne (57)	1995	Prospective	57	High-dependency units
Libreri (58)	1995	Retrospective	1,787	Staff attitudes
McLeod (59)	1995	Prospective control		APS versus no APS on 2 surgical wards, attitudes of ward staff
Rapp (60)	1995	Retrospective matched control	360	APS in patients with prior opioid consumption
Tsui (61)	1995	Retrospective	1,443	Cardiopulmonary derangements 4.1%
Breivik (62)	1995	Retrospective	5,749	2-center study
Fleming (63)	1996	Retrospective	1,222	Quality assessment of PCA
Maxwell (64)	1996	Retrospective	86	Descriptive study
Coleman (65)	1996	Prospective sequential	323	1 hospital before/after an acute pain nurse
Fugère (66)	1996	Retrospective sequential	3,404	1 hospital before/after an APS
Pesut (67)	1997	Retrospective sequential	178	1 hospital before/after APS
Mackintosh (68)	1997	Prospective sequential	206	1 hospital before/after an acute pain nurse
Tsui (69)	1997	Retrospective	2,509	Adverse events
Shah (70)	1997	Retrospective	2,024	Preliminary experiences with an APS
Wong (71)	1997	Retrospective	1,268	2 yr experience
Gabrielczyk (72)	1997	Prospective sequential	121	1 hospital before/after an acute pain nurse
Tsui (86)	1997	Prospective sequential control	578	APS reduces morbidity compared with non-APS
Harmer (30)	1998	Prospective sequential	2,738	15 hospitals in UK before/after APS
Burstal (73)	1998	Prospective	1,062	Descriptive study
Tighe (74)	1998	Prospective sequential	1,518	1 hospital before/after APS
Bredahl (75)	1998	Retrospective	104	Preliminary experiences with an APS
Chen (40)	1998	Prospective	1,275	Incident reporting
Lempa (46)	1998	Prospective control	498	2 wards compared, 2 with surgeon-based APS
Miaskowski (76)	1999	Prospective comparison	5,873	23 US hospitals (12 with APS)
Sartain (77)	1999	Prospective sequential	605	1 hospital before/after a physician-based APS
Ready (78)	1999	Retrospective	2,114	14 yr experience
Bardiau (79)	1999	Prospective sequential	1,975	Experiences with an APS in a general hospital
Brodner (80)	2000	Prospective	6,349	APS, fast-track protocol, and outcome
Salomäki (81)	2000	Prospective sequential	400	APS versus non-APS morbidity
Trials				
Stacey (82)	1997	Prospective (historical control)	80	PCA: APS or surgeons?
Rose (83)	1997	Prospective sequential control	5,166	Education and feedback
Hammond (84)	2000	Prospective	1,045	Quality assurance method
Carr (85)	2000	Prospective	85	Effect of postoperative pain on rehabilitation

PCA = patient-controlled analgesia.

The studies were classified as prospective when stated so, when a prospective design was obvious, or when institutional approval was obtained before the start of the study. If none of these criteria was fulfilled, then the study was designated as retrospective. Of the 25 prospective studies identified, 5 were controlled studies, including 1 using historical controls, and 10 studies used a sequential analysis with outcome assessment before and after provision of a formal APS. Twenty-three studies used retrospective data: two studies used a sequential analysis, and one study used a matched control. The outcome variables most frequently studied were pain ratings, treatment-related side effects, and adverse events (Fig. 2). Postoperative complications, cost issues, or length of hospital stay was reported in 11 articles, including 7 prospective analyses.

Pain Ratings

Sequential Studies and Controlled Studies. In the 12 studies ($n = 15,265$) containing sequential analyses (30,50,65,67,68,72,74,77,79,81,83,86) with assessments before and after the introduction of an APS program, 9 studies ($n = 9,921$) indicated a lower pain score at rest (30,50,65,68,72,74,77,79,81), and 7 studies ($n = 11,845$) indicated a lower pain score during dynamic conditions (30,50,65,77,81,83,86). In 8 ($n = 12,483$) (50,68,74,77,79,81,83,86) of the 11 positive outcome studies, all of which were prospective, a statistically significant difference was observed. In the 3 remaining studies (30,65,72) ($n = 3182$), statistical analyses were inadequate, either because of the nonrandomized nature of the study (30) or because of an insufficient number of patients (72). The overall reduction in the percentage of patients who experienced moderate to severe pain varied from 0% (67,83) to 8%–27% (30,65,68,72,74,77) at rest and from 19%–64% (30,68,74,77,81) during activity.

In the largest prospective sequential study (83), the introduction of an intensive education program in pain management for anesthesiologists, combined with individualized feedback, was associated with a significant decrease in activity-related pain scores ($P < 0.01$) assessed 6 h after discharge from the postanesthesia care unit (PACU). However, at the control hospital without active interventions (comprising 34% of the study patients), a similar decrease in pain scores was observed during the observation period. A change in the practice of pain management, assessed by the postoperative prescription pattern of analgesics and by the use of nerve blocks and PCA, was, however, significantly more common at the APS hospital. This study deserves attention because it is the only sequential APS study to use a control hospital. Why the introduction of an APS was not associated with a

decrease in pain ratings may depend on several factors. First, a confounding factor in the study was that anesthesia residents in the 2-yr study period rotated between the study hospital and the control hospital, which obviously could have influenced practice in the control hospital. Second, during the observation period 1992 to 1994, changes in general attitudes toward pain management in regard to the more effective use of nonsteroidal antiinflammatory drugs (NSAIDs) and PCA may have affected the result. Finally, and perhaps most important, several noncontrolled, sequential studies, most of them prospective, indicate that educational measures have to be combined with preoperative information to the patient (50,68,77), guidelines (68,74), treatment algorithms and protocols (30,50,74), formal assessment and recording of pain (30,50,77), supervision of pain management by an acute pain nurse (65,68), or daily pain rounds by an APS (65,66,68,77) to improve patient pain ratings.

In a prospective study by Gould et al. (50), the effect of 5 different clinically relevant sequential changes in postoperative pain management after general surgery was observed during a 9-mo period ($n = 2035$): introduction of a pain chart, a conventional treatment algorithm, infiltration of the incision with a local anesthetic, extended patient information, and introduction of PCA devices. The median visual analog scale (VAS) scores after major surgery ($n = 1421$) decreased significantly during rest from 45 (95% confidence interval, 34–53) to 16 (10–20), during movement from 78 (66–80) to 46 (38–48), and during deep inspiration from 64 (48–78) to 36 (31–38). Statistically significant changes were observed only after the two first interventions, i.e., the introduction of a pain chart and a conventional treatment algorithm.

In a very large prospective study including 25 hospitals in the United States ($n = 5837$), by Miaskowski et al. (76), patient ratings of worst pain were significantly less in hospitals with an APS ($n = 12$) compared with hospitals without an APS ($P < 0.00001$). Although the reduction in pain on a numeric rating scale (0–10) was very small, from 7.1 to 6.8, the reduction in the number of patients with moderate to severe pain was 9% at the hospitals providing an APS (absolute numbers were not reported). A prospective study assessing a surgeon managed APS indicated a significantly improved pain score compared with control ($P < 0.001$), at rest (18 vs. 43) and during dynamic conditions (42 vs. 49) (46). However, the use of different scales and assessment conditions (rest/mobilization) makes comparison between studies difficult.

Pain Ratings: Conclusion. Available data indicate that implementation of APSs or APS-like programs is associated with a significant decrease in patients' postoperative pain ratings. However, there are several unanswered issues: the contribution of increased awareness and importance of postoperative analgesia,

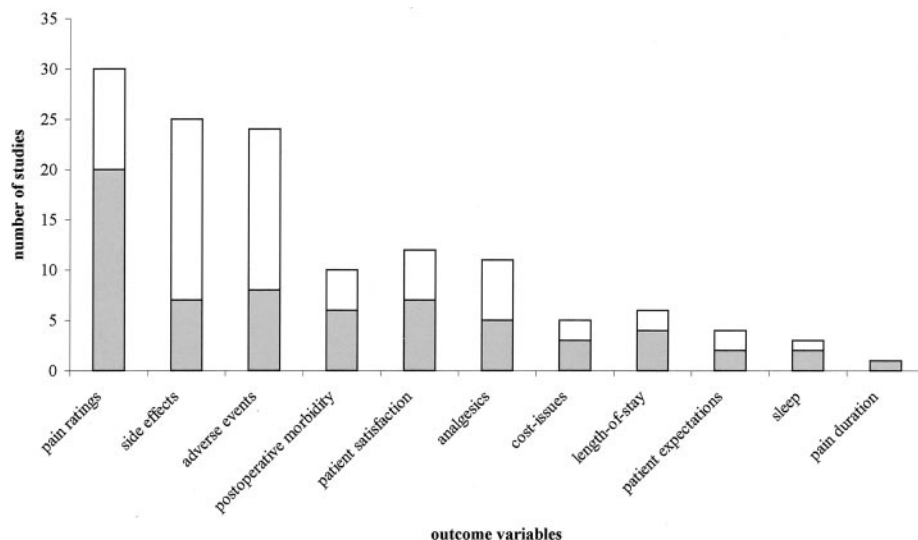


Figure 2. Number of studies assessing outcome variables (shaded parts of columns indicate the number of prospective, sequential studies).

the introduction of more effective regimens (i.e., epidural analgesia), the placebo or undefined effects of the twice-a-day visits of the APS (87,88), and whether there are any specific advantages of APS interventions in high-risk or acute surgical patients.

Side Effects

The most frequently investigated treatment-related side effects were postoperative nausea and/or vomiting (PONV) (20 of 25 studies), pruritus (15 of 25), urinary retention (7 of 25) and sedation (7 of 25).

Nausea and Vomiting. The incidence of nausea reported in APS studies was influenced by sex (49,69), age (69), and surgical (49,69,70) and anesthetic (69) procedure, which is consistent with the literature (89). A significantly less frequent incidence of patient-reported nausea, assessed within 24 h after discontinuation of the primary analgesic modality, was observed in hospitals with an APS compared with control hospitals (14% and 22%, respectively) (76) ($P < 0.0001$). However, 4 sequential studies (30,74,77,81) ($n = 5261$) did not find any significant difference, although a similar trend was observed in 2 of the studies (30,74). The management of PCA by an APS seemed to reduce the incidence of postoperative nausea compared with management by a ward physician, despite an increase in opioid consumption (82). However, although PONV may be decreased by an APS, the mechanisms remain unclear as to the role of increased awareness, new strategies for antiemetic treatment, or opioid rotation.

Sedation. Although several retrospective studies ($n = 10,987$) have not been able to demonstrate any effect on postoperative sedation score (48,54,70,81,90), in the prospective study by Miaskowski et al. (76), the percentage of patients reporting frequent sedation was significantly smaller at hospitals with an

APS (15% versus 26%). The incidence of sedation has, in retrospective APS studies, been reported to be 0%–7% (48,54,70,90), which could be related to different scoring systems or to a more extensive use of postoperative opioids, as in the study by Miaskowski et al. The incidence of sedation is probably less frequent for epidural analgesia than for opioid-based PCA (48,54,70,90). Unfortunately, APS data on sedation are too heterogeneous to make any valid conclusions.

Urinary Retention. Surgery, anesthesia, and postoperative analgesia are factors that contribute to postoperative urinary retention (91), which may lead to urinary tract infections (92). Treatment by an indwelling catheter for a prolonged period, however, increases the incidence of urinary tract infections (93), septicemia, and mortality (94).

The only sequential study on the effects of postoperative analgesia on the incidence of urinary retention reported an incidence of 5% and 9% (not significant), respectively, before and after the introduction of an APS, compared with an incidence of 6%–7% at the control hospital (83). A study by Stacey et al. (82) indicated a less frequent incidence of urinary retention when PCA was managed by an APS compared with management by primary ward physicians (5% and 28%, respectively) ($P < 0.01$). Although the morphine dose increased by 35%–100% in both studies after the introduction of an APS, it is interesting to note that the incidence of urinary retention did not increase. In contrast, two retrospectively conducted non-APS studies have indicated at least a sixfold increased incidence of urinary retention in patients receiving PCA compared with IM morphine after appendectomy and hysterectomy (95,96). In the study by Stacey et al., the decreased incidence of urinary retention was probably related to an increased attention to micturition problems on wards cooperating with an APS. Although

several other studies indicate an increased use of opioids after the introduction of an APS (30,65,67,82), future studies should evaluate the implementation of opioid-sparing strategies, including use of regional blockade and NSAIDs on postoperative micturition problems.

Side Effects: Conclusion. Few studies have systematically and in a prospective, controlled manner investigated the incidence and severity of side effects in an APS-based postoperative setting. This is unfortunate, because patients' perception of the efficacy and quality of postoperative care may depend on the intensity of the side effects experienced (97). The introduction of an APS may have been associated with less PONV and urinary retention, but these effects are again difficult to separate from common awareness and improved treatment strategies of these postoperative problems, as opposed to specific effects of improved analgesia by the APS. Also, the large variability in APS function and provided service preclude firm conclusions on potential improvement in outcome.

Expectation and Satisfaction

Four studies (30,47,48,76) ($n = 10,312$) assessed patients' preoperative expectations of the postoperative pain treatment, 12 studies (46,55,65,70,71,74,76,77,78,81,86,90) ($n = 25,769$) assessed satisfaction with the pain treatment, and 2 studies (47,67) ($n = 279$) examined staff expectations of and attitudes about an APS.

Patients who were cared for by an APS were more likely to report less pain than expected after surgery (30,76). In 2 (65,74) of 4 (77,81) prospective sequential studies ($n = 1841$ and 2846 , respectively), a significant improvement ($P < 0.01$) in satisfaction score after the introduction of an APS was seen. Miaskowski et al. (76), using a five-point Likert scale (1 = very dissatisfied; 5 = very satisfied) also observed that a significantly larger percentage of patients in the care of an APS were more satisfied than patients at control hospitals ($P < 0.00001$), although ratings of the two groups were fairly similar (mean, 4.4; SD, 0.8; and mean, 4.0; SD, 0.9, respectively). In a retrospective report, Ready (78) ($n = 6750$) also observed a frequent satisfaction rate; i.e., 89% rated 8 or higher on a VAS scale (0–10). Interestingly, the author stated that there did not seem to be any relation between the experienced severity of incident pain and the satisfaction score. In another retrospective APS study (90), the percentage of patients satisfied with PCA treatment ($n = 2922$) ranged from 86% to 95%, and with epidural treatment ($n = 2827$), between 80% and 98%.

A number of organizations (16,18,20,87) have suggested that measures of patient satisfaction should be included in quality or outcome assessment of pain management, although the relevance has been a matter of debate (98). First, patient ratings of satisfaction

of opioid based IV PCA are comparable to those of epidural analgesia with local anesthetics, although epidural analgesia is associated with increased analgesic efficacy (99–102). Second, the correlation between patient satisfaction and experienced pain severity seems to be very small ($r^2 = 0.02$) (103). Third, satisfaction depends more on the quality of communication between physician and patient (104). Thus, patient ratings of satisfaction as a measure of APS efficacy have to be evaluated cautiously.

Adverse Events

Twenty audits ($n = 35,032$) (39,49,51,54,61,63–66,69,70,71,73,75,77,78,80,86,90,105) and 3 trials ($n = 6291$) (82–84)—including 8 prospective studies ($n = 14,823$) (49,65,73,77,80,82,83,86), 1 national survey (35), 1 review (62), and 5 expert opinions (106–110)—addressed treatment-related adverse events: respiratory depression (17 articles), hypotension (10 articles), and motor blockade (7 articles). The overall incidence of complications (total = 43,576; epidural analgesia = 12,212) was 0.5%–1.2%, comprising in most cases opioid-related respiratory depression (39,49). The incidence of serious neurological complications related to the epidural analgesia was reported in 6 audits ($n = 12,940$) (39,40,49,73,80,86) and in 1 review (62).

Respiratory Depression. The incidence of serious postoperative respiratory depression requiring the administration of naloxone depended on the analgesic modality and was 0%–1.7% during fixed-rate morphine infusion (39,70), 0.1%–2.2% during PCA (39,49,54,62–64,66,69,77,90,105,111), 0.1%–1.0% with spinal infusions of opioids (66,69,70,71,75,51,62), and 0%–0.5% with a mixture of local anesthetics and opioid (54,66,69). In a study on incident reporting (40) ($n = 1275$) by an APS, three cases of respiratory insufficiency requiring admission to the intensive care unit (ICU) were reported. Two cases were attributed to inadequate analgesia, and one case was presumably caused by sedation during the use of PCA. There are no data available from the sequential studies indicating any change in the occurrence of respiratory depression after the introduction of an APS.

Hypotension. The incidence of clinically significant hypotension requiring APS intervention after epidural analgesia ranged from 0.7% (54,69,75) to 7.4% (77). In two prospective sequential studies, the incidence of hypotension decreased after the introduction of an APS, but the statistical significance level was not indicated (65,77). One audit on PCA-related complications reported an incidence of hypotension of 0.1%. In summary, the role of an APS to alter analgesia-related hypotension cannot be answered because of heterogeneity between studies.

Motor Blockade. The incidence of clinically significant motor blockade (Bromage grade >0) during epidural analgesia, impeding normal ambulation, was significantly increased for lumbar catheters compared with thoracically placed catheters (75,80,90): 7%–50% and 1%–4%, respectively. An unusual, prolonged, unilateral motor block in two patients lasting 4–10 days was reported in an audit (49). Two studies reported subjective motor weakness in 16%–21% (the level of the epidural catheter placement was not reported) (61,69). The role of the APS to reduce the incidence of motor blockade cannot be evaluated.

Neurological Complications. Neurological injuries caused by neuraxial blockade are in two categories: those that relate to performing the block and those related to an inadequate organization of the postoperative surveillance at the PACU, the high-dependency unit, or the ward (112). Neurological complications related to neuraxial blockade should be detected at the earliest possible stage to avoid permanent and severe disabling neurological injury (59). Several authors have emphasized that epidural analgesia with continuous infusion of local anesthetics on the wards requires visits including gross neurological examination by an APS at least once a day (13,113).

Serious epidural catheter-related complications reported included 1 case of cauda equina syndrome with persisting urinary incontinence ($n = 5602$) (80), 2 cases of meningitis ($n = 2287$) (62), 3 cases of intravascular migration of the epidural catheter ($n = 1062$) (73), and 5 cases of intradural migration of the catheter ($n = 4958$) (39,73,90). No case of confirmed epidural abscess was reported, but one suspected case was reported in the study by Burstal et al. (73). The role of an APS for neurological complications cannot be assessed.

Technical Incidents. In a study by Chen et al. (40), 53 incidents were reported during 1 yr in 1275 patients managed by an APS. Twenty-eight incidents were related to malfunctioning infusion devices and 15 incidents to erroneous drug dosing. Thirty-eight of the incidents were detected by the APS and the anesthesiologist. In a safety-assessment study (39), potentially severe complications were discovered in 0.5% of the patients (16 of 3016), without sequelae. The authors recommended continuous in-service training programs for medical and nursing staff, systematic recording of pain, identification of pain-relief responsibility, and continuous availability of suitably trained staff. In a large retrospective audit ($n = 5749$), 2 cases of accidental epidural opioid overdosing (2 of 2827) and 3 cases of IV PCA overdosing (3 of 2922) were reported (90). No sequential studies are available, and because of limited information on equipment malfunctioning and human and “system” errors, the effect of introducing an APS on technical incidents cannot be assessed.

Adverse Events: Conclusion. Implementation of pain management techniques with increased analgesic efficacy (epidural analgesia) may lead to an increase in treatment-related morbidity, i.e., from simple events such as urinary retention to serious complications such as an epidural hematoma. Assessment of safety aspects is an important objective of an APS, but the role of an APS to prevent or reduce these events has not been established. This is unfortunate, because implementation and supervision of epidural analgesia is one important objective of the APS.

Postoperative Morbidity

Five prospective audits ($n = 11,600$) (30,40,49,80,86), 4 expert opinions (108,114–116), and 3 reviews (42,62,117) reported on postoperative pneumonia and respiratory insufficiency. One study (30) additionally included an analysis of postoperative ileus and constipation.

The study by Wheatley et al. (49) reported that the incidence of lower respiratory tract infection, on the basis of retrospectively collected data, decreased from 1.3% to 0.4% after the introduction of an APS ($P < 0.01$). The authors speculated that the improved analgesia offered by the APS could have promoted the patients' ability to cough and cooperate with the physiotherapists. Pain relief was provided with either IV PCA (83%) or epidural analgesia (17%), but the authors did not comment on the relative infection rates between the two analgesic treatment modalities. A prospectively conducted sequential study (30) (Table 2) also seemed to indicate a decrease of lower respiratory tract infection, from 3.7% (53 of 1416) to 1.7% (23 of 1322), after the establishment of an APS. Unfortunately, no statistical significance levels were assigned, but a *post hoc* χ^2 test clearly demonstrates a statistical difference ($P < 0.001$).

An interesting prospective study by Tsui et al. (86) investigated patients with esophageal carcinoma undergoing esophagectomy. The patients either were supervised by an APS ($n = 299$) or received conventional treatment in a non-APS setting ($n = 279$). In the APS group, patients received opioid-based postoperative epidural or systemic-infusion analgesia, and in the non-APS group, intermittent IM morphine injections were administered. A significantly less frequent incidence of pulmonary ($P = 0.002$) and cardiac complications ($P < 0.001$), as well as a significant reduction in mortality ($P = 0.038$), were reported in patients in the APS group. The differences were significant only for patients undergoing a transthoracic procedure, compared with an abdominal procedure. These conclusions may, however, have been biased, because patients in the non-APS group were studied from 1986 to 1990, and in the APS group they were studied from

1989 to 1995. The improvement may thus reflect advances in the surgical technique, in the anesthetic methods, or in the general postoperative care instead of advantages conferred by newer methods of analgesia introduced by the APS.

The difficulties in making conclusions on the basis of results from APS studies on surgical outcome are further emphasized in a recent review of published controlled, randomized clinical studies of the effect of optimized perioperative pain relief on surgical outcome (3). In these studies, not necessarily conducted within the framework of an APS, there was no indication that improved pain relief improved postoperative outcome. The only exception was continuous epidural analgesia with local anesthetics, which significantly improved postoperative pulmonary outcome (1,3). Postoperative morbidity depends on multiple pathophysiological mechanisms, and unimodal interventional techniques such as pain relief, with or without an APS, may be inadequate to control and improve surgical outcome (118). However, adequate pain relief is a prerequisite for improvement in outcome (118).

Hospital Stay and Cost Issues

Ten audits ($n = 22,264$), 6 expert opinions, 4 general reviews, and 3 trials ($n = 5,246$) were included.

Hospital Stay. Four prospective studies examined length-of-stay issues (46,76,86,83). One study reported that patients cared for by an APS were discharged significantly sooner than patients at control hospitals (mean \pm SD, 2.3 ± 5.2 days and 2.8 ± 3.9 days, respectively) ($P < 0.001$) (76). In the study by Tsui et al. (86) in patients undergoing esophagectomy, the hospital stay was significantly reduced ($P = 0.005$) in the APS group compared with a non-APS group (21 ± 19 days versus 29 ± 33 days, respectively).

In another prospective controlled study from 1998, which included patients undergoing elective abdominal surgery, the hospital stay for patients in the APS group did not differ from that of controls (13.7 and 14.3 days, respectively) (46). These findings are consistent with a study by Rose et al. (83). There seem, however, to be serious objections as to the validity of hospital stay as an outcome variable. Although simple postsurgical discharge criteria are met by the postoperative patient (i.e., normal intake of food and fluids, normal voiding and defecation, and no signs of surgical complication), the actual time to discharge is highly variable (100). It has been demonstrated that a well defined postoperative care program, including thoracic epidural analgesia, early mobilization and oral nutrition, and a planned 48-h postoperative stay after elective colonic surgery, results in a median hospital stay of 2 days (119). Thus, assessment of the role of the APS in reducing hospital stay is possible only

when well defined care principles and postoperative recovery and discharge criteria are introduced (120).

Cost Issues. In a prospective study (80), the financial cost of running an APS staffed by 1 nurse and 1.5 physicians and including on-call service with 24-h availability was presented. The cost data for 1998 included 2124 patients undergoing various surgical procedures, with 50% undergoing major surgery (40% ASA physical status III-IV) (Table 3). Depending on the type of surgical procedure, treatment modalities were patient-controlled epidural analgesia (88%), IV PCA (10%), and continuous brachial plexus block (2%). Patient-controlled epidural analgesia was used for 5.6 (4.7) days, IV-PCA for 5.0 (4.7) days, and brachial plexus blockade for 4.3 (3.1) days. All patients under the care of the APS were visited twice a day, thereby involving the service 17-20 h a day. The estimated cost per patient, including cost of 24-h coverage, was US\$242, corresponding to a daily cost of US\$44. The introduction of a multimodal program with improved pain relief, stress reduction, and early extubation decreased the number of patients who required an ICU stay in the immediate postoperative period after major surgery. Because of a faster discharge from the high dependency areas, 443 ICU days were saved ($n = 356$), corresponding to US\$1392 per day. The authors included this savings in the total balance for 1998, giving a net savings of approximately US\$43 per patient. This is an interesting clinical study and is the only detailed study to address the important APS cost issue. Although several authors have argued for a low-cost nurse-based anesthesiologist-supervised model (65,68,79,122) as an alternative to the more expensive multidisciplinary APS (82,88,123), others have proposed an even more back-to-basics (124) cost-effective use of traditional analgesics.

Studies of health care costs include an analysis of the benefit of the intervention (125) with a well defined and relevant outcome measure. Cost analysis of acute pain management is impeded by the lack of a well defined baseline and well defined outcome assessments. There is no valid method to assign financial cost to differing levels of analgesia (126), and the effect of perioperative regional analgesia on economic outcomes has not been adequately examined (127). If specialized techniques provide benefits beyond pain relief, does the management of these techniques require a dedicated APS (116)?

Attempts at cost-benefit analyses that incorporate complication and outcome measures have been advocated, but no studies involving APS have been conducted. Cost-efficacy analyses of postoperative pain management will have to consider the costs of analgesics, devices, and nursing time, duration of stay in the PACU/ICU/surgical ward, and postoperative morbidity. Studies comparing different approaches in

Table 3. Studies of Cost Issues of Acute Pain Services

First author	n	Cost of staff	Disposables and drugs	Cost savings	Cost per patient	Morbidity data
Rawal (121)	20,000 ^a	US\$60,000	—	—	US\$3	—
Breivik (62)	1,000 ^b	US\$80,000 ^c	US\$50,000	—	US\$130 (US\$30) ^d	—
Breivik (62)	2,000 ^e	US\$130,000	US\$50,000	—	US\$90 (US\$20) ^d	—
Rawal (122)	20,000 ^a	—	—	—	US\$2-3	—
Tsui (86)	578	—	—	US\$200,000	—	Pulmonary complications, cardiovascular complications, mortality, hospital stay decreased
Tighe (74)	—	UK£35,000 ^f	—	—	—	—
Brodner (80)	2,124	US\$263,609	US\$247,884	US\$602,563 ^g	US\$242 (US\$-43) ^h	Hospital stay shortened
Salomäki (81)	400	—	—	—	US\$10	—

^a Annual number of surgical procedures.

^b Data from Oslo, Norway.

^c On-call staff wages not included.

^d Cost per day.

^e Data from Berne, Switzerland.

^f Disposables and drugs included.

^g Due to shortened postoperative intensive care unit stay.

^h Cost savings included.

a controlled environment will be needed to achieve an evidence base for the APS (115,127,128). Discussion on the implementation of high- or low-cost models will otherwise continue to be a matter of opinion.

APS and Future Strategies

From this review, segmenting the effects of an APS from the effects of the increased awareness of postoperative pain and/or improvements in postoperative pain techniques by multimodal pain-relieving techniques (129) and improvements in surgical technique (minimal invasive surgery) is difficult. Unfortunately, postoperative pain is still a problem that requires continuous awareness and efforts to improve treatment, despite the availability of an APS (130). However, the APS represents an instrument to improve pain relief, although the structure and cost-effectiveness need to be established (130). Also, in the context of improved pain relief and outcome, there need to be well defined quality criteria for the provided service (34,130). Most importantly, from this and other reviews (1,3), pain relief *per se* did not significantly improve postoperative outcome, with the exception of patient satisfaction and pulmonary complications. Thus, postoperative morbidity and hospital stay are dependent on multiple factors, including preoperative information, quality of analgesia, and existing programs for postoperative care and rehabilitation, including orders for mobilization, oral nutrition, and discharge criteria (118,131). Therefore, to elucidate the potential for postoperative pain relief and for an APS to improve postoperative morbidity and hospital stay, multimodal rehabilitation programs (fast-track surgery, clinical

pathways) must be established in which postoperative pain relief is integrated into an enforced rehabilitation program with early mobilization and oral nutrition, with well defined discharge criteria (131,132).

Finally, future strategies should focus on the integration of the APS and multimodal rehabilitation techniques on outcome in specific procedures, optimally performed as randomized, controlled clinical trials or in large-scale multicenter studies. Such a strategy is important for the future of APSs, because existing data suggest a major improvement in outcome, provided that the APS or other pain-alleviating strategies are integrated into multimodal rehabilitation programs (120,131,132). Otherwise, the survival of APSs may be threatened because of the present economic constraints in health care and the requirement for cost-effective therapeutic interventions.

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