

Avoiding Inadvertent Epidural Injection of Drugs Intended for Non-epidural Use

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SUMMARY

Inadvertent administration of non-epidural medications into the epidural space has the potential for serious morbidity and mortality. The aim of this study was to collate reported incidents of this type, describe the potential mechanisms of occurrence and identify possible solutions. We searched medical databases and reviewed reference lists of papers retrieved, covering a period of 35 years, regarding this type of medication incident. The 31 reports of 37 cases found is likely to represent a gross underestimation of the actual number of incidents that occur. "Syringe swap", "ampoule error", and epidural/intravenous line confusion were the main sources of error in 36/37 cases (97%). Given that no effective treatment for such errors has been identified, prevention should be the main defence strategy. Despite all the precautions that are currently undertaken, accidents will inevitably occur. We have identified areas for system-wide change that may prevent these types of incidents from occurring in future.

Key Words: ERRORS: injections, epidural, medication

Inadvertent administration of non-epidural medications into the epidural space has been associated with serious morbidity^{1,2} such as paraplegia or quadriplegia, sensory change and bladder/bowel incontinence. Patients may endure immense pain and suffering, and the health care personnel involved in such incidents may be left with their future career or practice in ruins³. In addition, the cost of litigation to the hospital can impact on the delivery of care to other patients. Our aim was to collate the reported mechanisms of such incidents and identify possible strategies for prevention.

METHODS

We performed an Ovid Medline search from 1966 to February 2002 and Embase search from 1988 to February 2002. Search terms were "epidural" and "(inadvertent or accidental)". We did a separate search for "Australian Incident Monitoring Study" (AIMS) and the terms "closed" and "claims". Further reports were identified from reference lists from the papers retrieved.

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RESULTS

Thirty-one reports of 37 cases were found using our search strategy⁴⁻³². Several papers^{4,5,12,18,19,25} reported two cases. All but two reports involved epidural injection of a drug intended for intravenous use^{2,32}. Table 1 shows the drug given and the effect on patient outcome. Table 2 outlines the contributing factors, as explicitly reported by the authors or apparent to us on reading the report, that led to the inadvertent administration of non-epidural drugs into the epidural space. For each contributory category, Table 2 also describes possible solutions that might prevent such an incident from occurring in the future.

DISCUSSION

Our literature search of inadvertent epidural injections is likely to represent a gross underestimation of the actual number of incidents that occur. Kasaba and colleagues³³ surveyed 31 anaesthetists in Japan, obtaining a 90% response rate. Ten anaesthetists (36%) had firsthand experience of inadvertent epidural injection of an intravenous drug, while five (18%) had experienced two such incidents. On review of closed claim studies in the United States³⁴, Canada³⁵ and the United Kingdom³⁶, the problem of administration of the wrong drug into the epidural space was not specifically identified. Currie and co-workers³⁷ found 144 incidents in the first 2000 incidents reported to the AIMS in which the wrong drug was nearly or actually given, and included inci-

TABLE 1
Non-epidural drugs administered into the epidural space and effect on patient outcome

Drug (references)	Effect
Intravenous induction agent bolus	
—Thiopentone (4*, 5*-7)	Burning pain/discomfort on injection (5, 6) Increasing drowsiness (4, 6-8)
—Methohexital (8)	Respiratory difficulty requiring intubation and ventilation (4) No effect detected in patient under general anaesthesia (7)
Muscle Relaxant	
Vecuronium bolus (9)	Prolonged neuromuscular blockade
Benzodiazepine and opioid	
Midazolam and fentanyl infusion (10)	Increasing drowsiness, hypoventilation Hypotension unresponsive to fluids
Opioid	
Morphine with 5% dextrose infusion (11)	Generalised coarse non-rhythmic tremor Marked disorientation to time and place
Sympathomimetic	
Ephedrine bolus (5, 12*)	Increase in blood pressure (5, 12) Tachycardia, severe occipital headache (12)
Antibiotic	
—Cefazolin (13, 14)	No effect detected (13-15)
—Amoxicillin/Clavulanic acid (15)	Back pain 5 hours following the start of infusion (16)
—Gentamicin infusion (16)	
Potassium chloride bolus (1, 17, 18*, 19*-23) and infusion (24, 25*-26) followed by "intravenous" diazepam 2 mg bolus (24)	Severe pain on injection (1, 19, 20, 23) Motor and sensory block (1, 17-20, 22-26) Bladder and bowel incontinence (1, 20) Tonic/clonic activity of lower limbs (1, 17, 20, 25) Respiratory difficulty requiring intubation and ventilation (1, 18, 22, 23) Sympathetic hyperactivity with diaphoresis, hypertension, tachycardia, tachypnoea and agitation (17-19, 22-26) Severe pruritus (22) Generalised convulsion (23) Residual complete analgesia below T7, Paraplegia, bowel/bladder incontinence until death 6 months later (1)
Magnesium sulphate infusion (27)	Intense burning sensation
20% hypertonic saline bolus (28)	Severe pain on injection Transient sensory deficit Autonomic dysfunction with tachycardia, hypertension and dyspnoea
Total parenteral nutrition and Intralipid infusion (29, 30)	No effect detected
Phenol containing ranitidine infusion (31)	No effect detected
Ether bolus (32)	Burning pain on injection Transient paralysis/sensory loss up to T8 Systemic effect of increased drowsiness
Paraldehyde (2)	Immediate onset pain and paraplegia progressing to permanent quadriplegia, altered sensation, urinary/bowel incontinence

*Indicates two cases in the report.

dents of inadvertent injection into the epidural space. "Wrong drug" errors occurred in the operating theatre, pain clinic and on the ward and the drugs were given either as a bolus or as an infusion.

Types of error

The recurrent themes in our identified reports include syringe swap^{4-9,12,13,32}, wrong ampoule for drug dilution^{1,17,18,22,23} and performance of loss of resistance^{19,20} technique for epidural insertion. Syringe swaps most commonly involve injection of intravenous induction agents, antibiotics and ephedrine

from similar sized syringes, which may or may not be labelled. Potassium chloride is frequently mistaken for normal saline, because the two solutions are presented in similar ampoules with different coloured writing^{1,17-20,22-24}. Gentamicin has also been mistaken for fentanyl, due to both ampoules having red flip tops and being kept in the same locked cupboard¹⁶.

Intravenous epidural line confusion seems to occur most commonly when the epidural giving set has an injection port^{14,24,27,30,31}. Two reports detailed direct connection of the intravenous line to the epidural filter^{10,29}.

TABLE 2

Factors contributing to the inadvertent administration of non-epidural drugs into the epidural space and possible preventive strategies

Category (References)	Number of reported incidents*	Possible solutions
Syringe swap	27	Prefilled syringe;
Same size (4-7, 9, 13, 15, 32)	10	Non Luer syringe coupling;
Unlabelled (4)	1	Bar coding
Person administering drug not person who drew it up (6, 8, 12)	4	
Similar location of syringes containing intravenous and regional medications (4-9, 12, 13, 32)	12	
Ampoule error	10	Prefilled syringe;
Similar ampoule (1, 16-23, 28)	10	Non Luer syringe with connector to ampoule that only accesses regional medications
Epidural/Intravenous line confusion	11	Non Luer coupling
Unlabelled catheter (10, 16, 24, 29)	4	
Unlabelled injection port (14, 24, 27, 30, 31)	5	
Inadequate knowledge (10, 29)	2	
Incorrect preparation of infusion solution at pharmacy level (12)	1	Avoid in-hospital manufacture of solutions; Bar coding of prescription to medication

*Some reports have more than one identified category of error.

Although much less common, human error can also occur in the pharmacy, with a case of an epidural morphine infusion prepared with 5% dextrose rather than normal saline¹¹.

Effects of inadvertent epidural injection

As Table 1 demonstrates, inadvertent injection of the wrong drug into the epidural space can have immediate and/or delayed effects. Pain and neurological symptoms immediately following injection are usually due to a direct drug or drug additive neurotoxic, pH or osmolality effect^{1,2,11,27-28,32}. The rate of application, the total dose^{18,22} and the concentration^{4,6,7} also play a role. Systemic effects of drugs, such as intravenous induction agents^{4,6-8} and vasopressors^{5,12}, occur over time as vascular uptake occurs into the epidural veins. Patients under general anaesthesia⁷⁻⁹ or infants¹³ are unable to complain. There is also usually a delay in onset of symptoms with drug infusion, because of slow vascular uptake over time^{11,16,24-27,31}.

Management of inadvertent epidural injection

Once the error has occurred, there is no definitive or effective treatment. Some practitioners choose to just observe the patient and provide symptomatic and supportive treatment as required^{1,19}, while others attempt to reduce the amount or concentration of the drug in the epidural space. Measures taken include aspiration of the epidural catheter^{7,32}, flushing with

distilled water²⁸ or saline^{4,5,7-9,14,24,26,31,32} and insertion of a second epidural catheter for lavage of the epidural space⁶. Epidural local anaesthetic has been used for symptomatic treatment^{4,6,12,13,28,29}, epidural or intravenous corticosteroids^{6,8,12,17,20,22,23,26,32} to reduce the inflammatory response and epidural hyaluronidase⁸ to aid the dispersion of the solution and reduce local concentration. None of these attempts to minimize the risk of an adverse outcome are of proven benefit and some can potentially worsen the situation, resulting in upward spread of drug and further symptoms²⁴. Local anaesthetic can also confuse the diagnosis of neurological injury. Resuscitative measures include intubation to support the airway^{1,4,18,22} and the administration of antihypertensive drugs^{12,17,22,25}. Symptomatic relief includes diazepam^{1,18,23,25}, midazolam²⁰ or opioids¹⁸ for muscle spasm, and reversal of systemic effects with antagonists, for example flumazenil and naloxone²⁴. Medication error is the single most preventable cause of patient injury³⁹. This includes wrong patient, wrong time and wrong drug, dose or route of administration. Given the fact that there is no effective treatment, and the potential for short and long term morbidity, prevention should be the main defence strategy.

PREVENTIVE STRATEGIES

Human error is a pervasive part of everyday life⁴⁰ and various strategies have been suggested to prevent the occurrence of such errors in relation to inadvertent epidural injection.

Drug preparation

It has been recommended that drugs should be drawn up separately, after reading the ampoule, with the syringe or bag labelled. This is especially important when there is no one person directly responsible for drug administration (for example when two anaesthetists are attending the same patient). Only drugs that are required should be drawn up or kept in the vicinity, to avoid errors such as potassium chloride being mistaken for normal saline^{1,17-26}. Others suggest that emergency drugs such as ephedrine should be kept physically separate or covered with tape to avoid accidental administration^{5,12}. A separate tray has been recommended for regional drugs, to avoid confusion with intravenous agents^{4-9,12,13,32}. Any doubtful drugs or syringes should be discarded.

Epidural drug administration strategies

It has been standard nursing practice for many years to double check with another person prior to administering any drug, but this may not be practical for the theatre anaesthetist and alternative measures are required. A computer system using barcode readers has also been used in an attempt to reduce parenteral drug administration error⁴¹. Slow incremental injection while maintaining verbal contact may allow earlier detection of problems.

Labelling

Packaging and labelling of ampoules with appropriate size writing and colour for easy reading helps to avoid the problem of drawing up solution from the wrong ampoule. Colour coding by the manufacturer or the hospital pharmacy for the class of drug can act as a visual cue³⁷. The addition of colouring to potassium chloride¹⁸ or the incorporation of a black cap⁴² has been suggested to avoid confusion with normal saline. However more errors occur due to "syringe swap" than "wrong ampoule"³⁷. Labelling of syringes does help to reduce this problem but does not totally alleviate it. Currie and co-workers found 63% of drug incidents associated with syringes occurred with correctly labelled syringes³⁷. We found five such cases in our study^{5,7,12,13}. Syringes with red plungers are now widely available for muscle relaxants and there are proponents for different coloured syringes for regional drugs as an additional visual cue³⁷. Clear labelling of epidural infusion bags, syringes, pumps, infusion sets, ports for injection and epidural catheters may improve safety. However there have been many cases where intravenous infusions have been inadvertently attached to epidural lines with access ports available^{10,14,24,27,29-31}.

Epidural lines and Injection ports

Epidural lines with injection ports should preferably be avoided altogether, because labels can accidentally fall off with exposure of the access port³⁰. Coloured stripes bonded to the tubing wall can also be used as a visual cue for epidural lines.

Physical separation of intravenous and epidural access points

Epidural and intravenous catheters should be placed physically separate from one another, to reduce the risk of confusion between the two systems²⁴. However, lack of education, knowledge or inattention have led to intravenous lines being directly attached to epidural filters^{10,29}.

System Change

Most wrong drug incidents involve latent errors, or errors waiting to happen. Systems can be designed to minimize contributing and precipitating factors, and to help detect and absorb the effects of such error⁴⁰. Fatigue, haste, distraction and inattention can degrade the ability of the anaesthetist to monitor a highly routine action that is done automatically with dissociation from the conscious control. This type of error occurs where a close, but not perfect, cue is accepted and acted upon³⁷. This can lead to the use of a wrong ampoule or wrong syringe or confusion between intravenous and epidural lines.

Despite all the precautions mentioned, incidents continue to occur. Table 2 describes some possible strategies that had the potential to prevent 97% of the reported incidents. Several workers have proposed the development of a system for regional equipment that is incompatible with the intravenous Luer system⁴³⁻⁴⁶. The implementation of such change would not only make inadvertent epidural administration less likely, but could also prevent intrathecal injections of intravenous drugs and inadvertent intravenous injection of epidural drugs. Such incidents have received increased attention recently^{43,47,48}. There have been at least 13 cases of inadvertent intrathecal administration of vincristine in Britain since 1985, ten of which have been fatal and three of which have resulted in permanent paralysis⁴⁷. Similarly, there are several reported incidents of inadvertent administration of epidural drugs intravenously⁴⁸⁻⁵⁰, two of which have proven fatal^{48,50}. Changing the calibre of the connectors on all regional equipment would make them incompatible with the intravenous system^{38,43-46}. In addition to this change, access to drugs used for regional anaesthesia needs to be addressed. For example, ampoules containing epidural or intrathecal

drugs could be made inaccessible to intravenous equipment, their Luer connections or needles. Although such system-wide change could make this type of incident almost a thing of the past, the numerous challenges presented would require professional, financial and political support³⁸.

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