EXTRADURAL, SPINAL OR COMBINED BLOCK FOR OBSTETRIC SURGICAL ANAESTHESIA

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One of the outstanding features of obstetric surgical procedures carried out under regional anaesthesia is that the patients are seldom given premedication, peroperative sedation or light general anaesthesia which might mask any deficiencies in the local anaesthetic block. Before delivery this is in the interests of the fetus, which may be affected by any drugs given to the mother. For procedures carried out after delivery, sedation or anaesthesia interferes with the mother's enjoyment of her new baby, and may even jeopardize her safety if her respiratory protective reflexes are depressed. This is in contrast with other branches of anaesthesia in which regional techniques are popular—especially orthopaedics, where supplementary sedation or anaesthesia is commonplace. It is in obstetric anaesthesia, therefore, that the differences between extradural and spinal block may be most apparent, and in choosing between them it is necessary that the anaesthetist understands the relative merits of the two techniques.

In accordance with popular usage, “anaesthesia” is used in this article, rather than “analgesia”, although much of the time only freedom from pain is implied. In addition, “subarachnoid” and “intrathecal” are used synonymously with “spinal”.

FACTORS AFFECTING THE CHOICE BETWEEN EXTRADURAL AND SPINAL ANAESTHESIA

General factors affecting the choice between extradural and spinal anaesthesia always include the expertise of the anaesthetist and the availability of suitable drugs and equipment. Historically, spinal anaesthesia antedated extradural anaesthesia by a few years, but its popularity in the United Kingdom was dealt a severe blow in the 1950s by the publicity surrounding the Woolley and Roe case [15], when two patients on one operating list became paraplegic. Only recently has this type of regional block returned to favour. In the meantime, much expertise in its use was lost, as indicated by the recent “discovery” that inserting the spinal needle through the dura mater with its bevel orientated laterally reduces the incidence of spinal headache [52], although this had been recommended more than 40 years previously [26, 48].

In the United Kingdom, the combination of the strict requirements of the Committee on Safety of Medicines (CSM), the low usage of spinal anaesthesia for many years after the Woolley and Roe case and a virtual monopoly of the local anaesthetic market by one drug company, has led to a very restricted choice of agents. Only one hyperbaric spinal solution—heavy bupivacaine—has a product licence in the United Kingdom, and only the various formulations of bupivacaine are available in packaging suitable for extradural block. Two per cent lignocaine with adrenaline, currently popular for operative obstetrics, must be prepared by adding adrenaline to the plain solution, a technique which has some advantages but also has potential for contamination or errors in dilution. In some other countries, the choice of local anaesthetic agents for extradural and spinal block is so wide as to be almost confusing, but it does give the individual anaesthetist greater flexibility in choosing the agent for a particular purpose.

Several other factors affect the choice between extradural and spinal block.
**Speed of Onset**

The time required to prepare a patient for surgery using a regional technique consists of two parts: the time taken in performing the technique and the time from injection of the drug to the onset of surgical anaesthesia. Because the technique is simpler, it should require less time to perform a spinal than an extradural block, especially if a catheter is introduced in the latter. After injection intrathecally, drugs usually have more rapid onset of effect than after extradural injection, although there is some variation in rate of onset between individual drugs injected by both routes. Chloroprocaine (not available in the United Kingdom) is an exception, in that extradural administration may result in almost as rapid an onset of effect as is obtained with other drugs given intrathecally.

The difference in rate of onset of surgical anaesthesia also varies with different operation sites. For example, perineal anaesthesia is relatively slow in onset after extradural block, because of the distance of the sacral roots from the site of injection, whilst after spinal block it occurs almost immediately.

Various modifications may be made to extradural anaesthesia in order to hasten its onset.

**Alkalization (pH adjustment)**

Local anaesthetics are weak bases and poorly soluble in water. They are usually supplied commercially as the hydrochloride salts with a relatively low pH to keep the base in solution. Adrenaline-containing solutions are particularly acidic. In solution, such weak bases exist in two forms: cationic and non-ionized free base. It has been shown that, while the cationic form interacts with the axonal membrane to block nerve conduction, only the lipid-soluble free base penetrates the nerve sheath [67–69]. The proportion of the latter may be increased by increasing the pH of the solution; clinically this is achieved by adding bicarbonate to the local anaesthetic solution. The amount required varies between agents [35], but the value to which the pH may be increased is limited by precipitation of the free base at about pH 7.

Significant reductions in onset time have been claimed for extradural mepivacaine [28], lignocaine [22], bupivacaine [24] and chloroprocaine [64, 75]. All investigators do not agree with these findings, however, especially with respect to bupivacaine [76]. It is difficult to reconcile such differences, but they may be explained at least partly by use of different end-points (e.g. onset time, onset of surgical anaesthesia, time to peak effect) or different methods of measuring levels of analgesia (e.g. pinprick, electrical stimulation, loss of temperature sense). Further clarification is required, but while the results with lignocaine appear convincing, those with bupivacaine were statistically significant, rather than clinically dramatic, in the series reported by Douglas and colleagues [24], in which the average time to peak effect was reduced from 25 to 18 min.

**Carbonation**

Bromage and colleagues [6] showed that carbonation decreased the latency of onset of lignocaine (by about 33%) and prilocaine (by about 25%). Not all subsequent studies have confirmed these results [49, 53]. Carbonation may produce this effect in several ways: carbon dioxide itself may cause some direct neural block, increased concentrations of carbon dioxide may result in an increase in the cationic form of the local anaesthetic within the axoplasm, and there may be an increase in the pH of the solution as carbon dioxide is lost on opening the ampoule. Brown and colleagues showed that carbonation had little effect on the speed of onset of anaesthesia with bupivacaine [7].

**Warming**

Mehta and colleagues [50] and Howie and Dutton [32] showed that warming 0.5% bupivacaine to approximately 38.0 ºC produced a reduction in onset time. The improvement (of about 20%) hardly merits the inconvenience of the recommended warming of both the extradural solution and tray.

**Efficacy**

Apart from safety, efficacy is the most important aspect of a local anaesthetic block especially if, as in obstetrics, i.v. or inhalation supplementation is undesirable. After extradural injection, local anaesthetic solution must percolate through fat and veins to reach the nerve roots; as many as 38 pairs may require blocking to provide surgical anaesthesia up to the 4th thoracic dermatome. It is perhaps surprising that extradural blocks work as well as they do. However, in awake patients, extradural block may sometimes be patchy, asymmetrical or limited in extent, and may remain so despite increments of local anaesthetic drug. In
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recent years, evidence has accumulated to explain these findings. Based on surgical and postmortem dissections and radiography of the extradural space, Luyendijk [45-47] described a median dorsal fold of the dura mater with variable attachment to the vertebral arches and ligamentum flavum. Clearly, this fold could direct local anaesthetic solution wholly or partly to one side of the extradural space. Using polyester resin injection studies of the extradural space, Husemeyer and White [34] confirmed the presence of this midline dorsal fold, with a tendency for the resin to become compartmentalized rather than distributed symmetrically. The presence of variable midline bands and structures in the posterior extradural space was reported also by Blomberg [4] using extraduroscopy and by Savolaine and colleagues, using computed tomography scanning [72].

In the cerebrospinal fluid of the subarachnoid space, local anaesthetic solutions behave usually as if totally unimpeded by physical barriers. Sometimes there may be difficulty in extending or limiting a spinal block, but patchiness is most unusual. Indeed, efficacy is one of the main advantages of this technique. Subarachnoid septa do exist [55], especially in the midline posteriorly and posterolaterally, but they are incomplete and a unilateral subarachnoid block as described by Armstrong [3] is exceptional.

Assessment of efficacy of regional anaesthesia for Caesarean section is made usually either by a simple scoring system or by noting the proportion of patients requiring i.v. or inhalation supplementation. Using these criteria, Norton, Davis and Spicer [56] compared 0.5% bupivacaine plain with 2% lignocaine with adrenaline 1:200000 and found that only 50% of patients were completely comfortable in both groups. Reid and Thorburn [65], comparing the same drugs, had similar success with bupivacaine, but only 29% of those given lignocaine required supplementation. Tackley and Coe [77] also found that 50% of patients required peroperative supplementation after extradural block with 0.5% bupivacaine plain for elective Caesarean section, but none of a small number given pH-adjusted 0.5% bupivacaine with adrenaline 1:200000 required supplementation. Similarly, Scott and colleagues [74] achieved adequate analgesia for lower abdominal surgery in only 60% of patients when using 0.5% bupivacaine, although the success rate was increased to 90% by use of 0.75% bupivacaine. It seems that, in some subjects, the anatomical structures mentioned above may prevent the 0.5% bupivacaine from reaching the nerve roots in adequate concentration but, when 0.75% bupivacaine is used, the small amount reaching the nerve roots may still be sufficient to produce effective analgesia. Although some of the drugs in the studies noted above were given in divided doses, it is likely that a slow incremental technique with repeated “painting” of the nerve roots may be more successful in producing satisfactory anaesthesia. This technique, which may be very time consuming, was recommended by Crawford [18] without any maximum limit being put on the dose of drug.

Extradural opioids

Since the discovery of opioid receptors in the brain and spinal cord and of endogenous opioids, the use of extradural opioids has been evaluated in several painful conditions. In acceptable doses, alone, they do not provide adequate pain relief in labour, but they have become popular, especially in the United States, in combination with local anaesthetic solutions for this purpose. More recently there has been growing enthusiasm for the addition of opioids to local anaesthetic solutions in order to improve the efficacy of pain relief during extradural anaesthesia for Caesarean section. A survey of members of the Society for Obstetric Anaesthesia and Perinatology in 1987 [39] showed that 62% were adding an opioid to local anaesthetic drugs—perhaps indicating dissatisfaction with unmodified local anaesthetic block. The commonest supplementary agent was fentanyl, given in a dose of 100 μg after delivery of the baby. The percentage of American obstetric anaesthetists now using opioids in this way is probably much greater. The reports by Preston and colleagues [59], who added fentanyl to 2% lignocaine with adrenaline and Gaffud and colleagues [27] who added the same drug to 0.5% bupivacaine with adrenaline, are typical of several studies of this technique. It is interesting to note that, while both groups reported an improvement in efficacy of extradural anaesthesia, complete pain relief was not produced in all patients.

Addition of adrenaline

The main reason for addition of adrenaline to local anaesthetic solutions is to delay absorption from the site of injection, thus increasing the duration of action and reducing systemic toxicity.
This effect is marked with lignocaine, but is less
(if at all) evident with bupivacaine. It is debatable
if adrenaline increases the intensity of the block
but, if so, it may produce this effect by direct
action on alpha-adrenergic receptors (which me-
diate analgesia) in the spinal cord. Laishley and
Morgan [41] compared 0.5% bupivacaine plain
and with adrenaline 1:200000 for elective
Caesarean section and observed a significant
reduction (from 45% in the former group to 25%
in the latter) in the number of those requiring any
form of extradural, inhalation or i.v. supplemen-
tation after an initial 100-mg dose.

Other agents
Several other supplementary agents have been
evaluated, including clonidine (an alpha-2-
adrenergic stimulator) [44], somatostatin (a tetra-
decapeptide) [13] and ketamine [58]. Results have
been inconsistent and, in common with opioids,
these agents seem to be more effective against
some types of pain than others. None has been
shown to improve surgical anaesthesia reliably.

Efficacy of Spinal Anaesthesia
Because of the ease of access of local anaesthetic
solutions to the nerve roots in the subarachnoid
space, a high success rate depends mainly on the
use of an effective drug and a technique which
ensures that it reaches the nerve roots in sufficient
concentration to last for the duration of the
operation. This is relatively difficult to achieve for
Caesarean section, for which the block must be
maintained in the upper abdominal segments
where "painting" of the nerve roots by the local
anaesthetic agent is least effective. Thus
Abouleish and colleagues [1] and Santos and
colleagues [71], using up to a maximum of 10 mg
of hyperbaric 0.5% bupivacaine found that many
patients required peroperative i.v. supplemen-
tation. On the other hand, Michie and his
colleagues [51] reported no need for supplemen-
tation in 20 patients in whom 12.5 mg (2.5 ml of
0.5% hyperbaric solution) was used—a result
consistent with my own experience using a fixed
dose of 14 mg (2.8 ml of 0.5% solution) in almost
all patients [unpublished observations].

Because of unpredictable spread in obstetric
patients, plain solutions of local anaesthetics,
which are approximately isobaric, are not
recommended for Caesarean section—even in
expert hands [70]. However, Van Zundert and
colleagues [80] reported excellent analgesia with a
low incidence of hypotension when a large volume
(10 ml) of 0.125% bupivacaine with 1:800000
adrenaline was used. However, some blocks did
reach the mid-cervical nerve roots.

Toxicity
In terms of drug toxicity, spinal anaesthesia is
outstandingly the safest of all regional and general
anaesthetic techniques. However, all local an-
aesthetic agents are toxic in large doses and in the
case of extradural anaesthesia the safe limits must
always be respected. This applies especially when
an extradural block which has been established
for pain relief in labour is extended for Caesarean
section. In these circumstances, toxic plasma
concentrations may be produced [78] and
convulsions have been reported [79]. Cardiac
arrest caused by bupivacaine has been reported in
the U.S.A. [2]; while this was reported to have
occurred after intravascular injection, the danger
is sufficient to make most anaesthetists reluctant
to use large doses of this agent. It should be noted
that the U.K. data sheet for bupivacaine no longer
recommends the use of 0.75% bupivacaine in
obstetric indications and the United States Food
and Drug Administration has also withdrawn
approval for its use in obstetrics.

Headache
Headache does not usually follow a correctly
performed extradural block, but may result if the
dura is punctured accidentally and is likely to
continue for as long as cerebrospinal fluid leaks
into the extradural space. The postural nature of
this headache, its frequent association with neck
ache and less often with photophobia, vertigo,
tinnitus or even cranial nerve palsies is well
known. It is also known to be (but not why it is)
commonest in women of childbearing age, gener-
ally commoner in women, less common in the
very old and almost unknown in the very young.
The incidence and severity are related to the size
of the needle puncturing the dura mater, so that
the greatest incidence (approximately 70%) is
seen when inadvertent dural puncture occurs with
a large extradural needle in pregnant patients [17].

In the past, the susceptibility of obstetric
patients to headache even after the use of relatively
fine needles has deterred anaesthetists from using
spinal anaesthesia, but recent improvements in
needle manufacture have made available a wide
range of excellent, sharp disposable needles in
sizes as small as 26 gauge. It is claimed that the
incidence of headache is reduced by needle insertion with the bevel parallel to the longitudinal fibres of the dura [52], although it has been disputed that such an arrangement of the dural fibres exists [23]. Even with 26-gauge needles inserted in this manner, several studies have reported a significant incidence of postural headache of 3–8%, which is consistent with an incidence of 3% in more than 1500 spinal blocks for several obstetric indications [unpublished observations]. Not all these headaches are severe, but an extradural blood patch is required occasionally and these few cases suggest that even finer needles should be used. Flaatten and colleagues [25] reported no postural headaches in 42 young patients (11 female) after the use of 29-gauge needles, and in a personal series (to date) of 130 anaesthetics for Caesarean section carried out using 29-gauge needles in a combined spinal–extradural technique there have been no reports of postural headache.

**Hypotension**

Extradural or spinal block only causes hypotension if the sympathetic outflow from the spinal cord is affected. Thus sacral block alone has no effect on arterial pressure, mid block to the lower thoracic dermatomes may have some effect and high block to the upper thoracic levels produces extensive sympathetic block, likely to cause hypotension. With extradural and spinal blocks of equal extent, a similar effect on arterial pressure might be expected. In practice, however, spinal blocks have a greater tendency to cause hypotension because the speed of onset of intrathecal block exceeds the rate at which compensatory physiological responses develop. Indeed Parnass, Curran and Becker [57] attributed the greater degree of hypotension when bicarbonate was added to lignocaine with adrenaline for extradural Caesarean section to the greater speed of onset of the pH-adjusted drug.

Other factors affect the degree of hypotension, including the state of hydration, blood loss, pre-existing cardiovascular disease and concomitant antihypertensive therapy. Regional anaesthesia to the upper thoracic dermatomes may produce bradycardia resulting from block of cardio-accelerator nerves although, in obstetric patients, severe bradycardia is unusual even with high blocks. In the latter weeks of pregnancy, the most important factor affecting arterial pressure is aorto–caval occlusion, which potentiates the sympathetic block.

The most important prophylactic measures against hypotension during the extensive sympathetic block inevitably caused by regional anaesthesia for Caesarean section are fluid preloading and maternal posturing to minimize aorto–caval occlusion. The full lateral posture should be maintained whenever possible [10]. It is debatable if crystalloids or colloids should be used for preloading, but most anaesthetists prefer the former; doubt has been expressed on whether or not colloids are more effective [61] and all are associated with anaphylactoid reactions, especially in unstressed patients. A vasopressor may be required, and for this purpose the predominantly beta-adrenergic stimulator ephedrine, which does not reduce placental blood flow [60], is the most popular agent. It has been given by various routes and doses, but the most flexible method during spinal anaesthesia for Caesarean section is a prophylactic i.v. infusion at a rate of administration titrated against arterial pressure [38]. During extradural Caesarean section, most anaesthetists would only give ephedrine if required. Another approach is to promote venous return by the use of elastic support stockings [30]. While this seems a rational measure, not all are convinced of its efficacy [42].

Hypotension in obstetric patients is variously defined as a reduction in systolic arterial pressure to a value less than 90 or 100 mm Hg, or a reduction in systolic arterial pressure by 20–30% of its preanaesthetic value. Using these definitions, it has been shown, using Apgar scores [5], fetal blood-gas tensions [19], intervillous blood flow measurements [36], ultrasound measurement of the fetal circulation [43] and neurobehavioural adaptation scores [16], that transient hypotension does not adversely affect the fetus.

**Effect on Respiration**

Before the significance of aorto–caval occlusion in pregnant patients was appreciated, cardiovascular collapse occurring during Caesarean section under spinal anaesthesia was attributed frequently to respiratory depression. It was assumed that this was caused by a combination of intercostal muscle paralysis from the high block and restriction of descent of the diaphragm by the gravid uterus. These incidents are now known to have been caused by aorto–caval occlusion. It appears that
respiration is well maintained, even when spinal anaesthesia affects the highest thoracic segments. It is likely that this is caused partly by the continued ability of the near-term pregnant woman to perform diaphragmatic breathing, and partly by the differential nature of both extradural and spinal blocks in their higher segments, motor function being less affected.

Using reduction in peak expiratory flow rate (PEFR) as a measure of ability to cough, Gamil [29] found that the majority of women during extradural Caesarean section maintained PEFR at values consistent with effective coughing. However, women with pre-existing respiratory disease may have impaired ability to cough in these circumstances, and Gamil recommended the avoidance of sedative supplementation. She also suggested that postoperative patients should not be nursed in the flat supine position until regression of the extradural block was complete.

**Continuous Technique**

One of the most frequently stated disadvantages of spinal compared with extradural block is that it is unwise to place a catheter in the subarachnoid space—that is, it is a non-continuous technique. Two reasons are offered, neither of which has been substantiated. The first is that infection is more likely to result than with an extradural catheter and the second is that a prohibitive incidence of post-spinal headache would result from the large size of the needle required to introduce the catheter.

Several series [21, 31, 37] of continuous spinal blocks have been reported with no evidence of infection, and it seems that the risk of infection has been exaggerated, at least when catheters are left in place for only a few hours.

In 1972, Kallos and Smith [37] reported a continuous spinal technique using 20-gauge catheters inserted through 18-gauge needles without any subsequent postural headaches. This surprising observation was supported more recently by Denny and colleagues [21], who reported only one postural headache in 117 patients using the same sizes of needle and catheter. The explanation for this remarkably low incidence of headache was suggested from the observation of Yaksh and colleagues [81] that, in cats with indwelling intrathecal catheters, an inflammatory response with fibrin deposition occurred round the needle hole in the dura mater. The mean age of patients in Denny's series was 63 yr, with more men than women, while Kallos and Smith's group, with a similar composition, were immobilized supine for 5 days (for surgical reasons). On the other hand, Giuffrida and colleagues [31] found an unacceptably high incidence (16%) of postural headache in 74 obstetric patients in whom continuous spinal catheters had been introduced through 21-gauge needles.

Another new development is the introduction of 32-gauge microcatheters which may be passed through some types of 26-gauge spinal needle [33]. If these catheters prove safe and reliable, they may permit continuous spinal techniques; for example, continuous spinal anaesthesia might be used during surgery to maintain a high intensity of anaesthesia, followed by more dilute concentrations of local anaesthetics (or even opioids) for postoperative pain relief. It is important that such techniques are considered only when the available facilities are adequate for their safe use.

**COMBINED SPINAL-EXTRADURAL TECHNIQUES**

As both extradural and spinal blocks have advantages, there should be some benefit in combining the two techniques, provided there is no increase in the incidence of complications. The combined technique, whereby a long spinal needle is introduced through an extradural needle, was first described for orthopaedic use by Coates [14] and by Mumtaz, Daz and Kuz [54]. Its use in obstetrics was reported first in 1984 [12], although Brownridge in 1981 [8] had described the technique using separate interspaces. Since then, several reports have appeared [9, 11, 20, 40, 62] and the combined technique has gained sufficiently in popularity for one equipment company (Braun Medical Ltd) to have produced packs with several matching sizes of extradural and spinal needles. Usually, 25- or 26-gauge spinal needles are used, but trials have been carried out with even finer needles (see above). This combination of techniques provides the rapid onset and reliability of spinal block with the facility to modify the analgesia (by supplementation through the extradural catheter) if it is not effective. In the postoperative period, local anaesthetic, opioids, or both, may be administered by incremental or continuous techniques. A further advantage of this technique is that, during insertion, the extradural needle guides the fine spinal needle almost to the subarachnoid space.
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With the combined technique, greater flexibility is available in providing regional anaesthesia. For example, spinal block may be used alone for the surgical procedure or combined with extradural anaesthesia from the outset. Another variation advocated for Caesarean section [63] is the limitation of the spinal anaesthetic to the lower segments and extension with the extradural. Other possibilities, where proper facilities are available, are to give an intrathecal injection of an opioid in labour, adding extradural analgesia if and when required [Gutsche, personal communication], or to use intrathecal opioids combined with local anaesthetic agents for both peroperative and postoperative pain relief [1].

CONCLUSION

Several factors must be taken into account in choosing between extradural and spinal anaesthesia for surgery. Spinal block, especially in the sacral segments, provides more rapid onset of surgical anaesthesia than extradural block, although the rather short-acting chloroprocaine, not available in the U.K., may be almost as rapid when given by the extradural route.

Because spinal local anaesthetic solutions are injected into the cerebrospinal fluid directly bathing the nerve roots on which they are to act, they usually produce effective anaesthesia; extradural solutions must overcome variable anatomical barriers. The more potent and concentrated the local anaesthetic drug, the more likely it is to be effective despite anatomical barriers. Bupivacaine 0.75% approached this ideal, but fears of toxicity led to withdrawal of its approval for use in obstetrics. While discussing extradural block for surgery, Scott [73] stated “The evidence that it is not possible with current local anaesthetic drugs to produce 100% analgesia in 100% of patients is not hard to find” and anaesthetists still await a drug with outstanding extradural efficacy. A new agent—ropivacaine—is currently undergoing clinical trials.

Because of the very small doses used for spinal anaesthesia, drug toxicity is most unlikely. With extradural anaesthesia, drug toxicity is more likely to be encountered, especially when large volumes of local anaesthetic are used in an attempt to overcome a recalcitrant block. If an agent is to be injected over a period of time, the maximum safe dose may be uncertain. In the case of bupivacaine, however, an attempt has been made to give some guidelines [66]. Toxic convulsions have been described when extending an extradural already in use for labour for Caesarean section [79], and when such blocks are difficult to extend it is safer to replace the extradural catheter or even to add a spinal block.

The rapid onset of spinal anaesthesia makes hypotension more likely when block involves the sympathetic outflow from the spinal cord. This implies that particular vigilance is required during spinal anaesthesia for Caesarean section, where aorto-caval compression increases the likelihood of hypotension.

Surprisingly few general surgical patients complain of headache following the introduction of intrathecal catheters through quite large needles. However, we might expect a higher incidence in pregnant women, limiting the usefulness of such devices in obstetrics. While microcatheters may resolve this difficulty, their practicality has yet to be demonstrated.

Finally, combined spinal-extradural techniques provide the speed and reliability of spinal anaesthesia with the advantages of a continuous catheter technique and greater flexibility in providing high quality analgesia, both during and after surgery.

REFERENCES


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