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Current status of the combined spinal-epidural technique in obstetrics and surgery

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Epidural and spinal blocks are well-accepted neuraxial techniques but both have several disadvantages. Combined spinal-epidural (CSE) can combine the best features of both techniques and reduce or eliminate these disadvantages. It provides the rapidity, density, and reliability of subarachnoid block with the flexibility of catheter epidural technique to extend the duration of anesthesia/analgesia (and to improve spinal block). It is an excellent technique for determining minimum intrathecal drug doses. Although most commonly employed in obstetric practice, CSE is also used in a wide variety of non-obstetric surgical procedures including orthopedic, vascular, gynecological, urological, and general surgical procedures. The needle-through-needle technique remains the most commonly used method to perform CSE. Several technical variations including Sequential CSE and Epidural Volume Extention (EVE) are commonly used particularly in obstetric and high-risk patients such as those with cardiac disease where a slower onset of sympathetic block is desirable. The risks of complications such as epidural catheter migration through the dural hole, neurological complications, and subarachnoid spread of epidurally administered drugs are possible but have not been a clinically relevant problem in the 40+ years of their existence.

In obstetrics, CSE is used for labor pain because it produces rapid-onset analgesia with reduced local anesthetic consumption and

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less motor block. The epidural catheter placed as part of a CSE is more reliable than a catheter placed as part of a conventional epidural. Less breakthrough pain throughout labor is noted and fewer catheters require replacing. Side effects of CSE include greater potential for hypotension and more fetal heart rate abnormalities. CSE is also used for cesarean delivery. The main purpose is to decrease the spinal dose so that spinal-induced hypotension can be reduced. However, reducing the spinal dose requires an epidural catheter to avoid intra-operative pain when surgery is prolonged.

Introduction

As the name suggests, the combined spinal-epidural (CSE) technique is an amalgamation of two of the oldest anesthesia techniques in regional anesthesia. The first description of CSE is generally attributed to the New York surgeon, Soresi [1] who, in 1937, described administration of procaine epidurally followed by intrathecal administration of the drug through the same needle. However, a recent report suggests that Polish surgeon Rodzinski first presented the ‘Combined lumbosacral anaesthesia’ at the meeting of Polish surgeons in Warsaw in 1922 [2]. A single-shot sacral block was combined with a lumbar spinal block for a variety of lower abdominal, orthopedic, urological, and gynecological procedures and cesarean section [2]. In 1979, Curelaru [3] reported placement of an epidural catheter followed by a spinal block of one or two segments below for abdominal, urological, and orthopedic surgeries. In 1981, Brownridge [4] reported the use of CSE in cesarean section with spinal and epidural needles introduced at different levels. In 1982, the needle-through-needle technique was described for orthopedic surgery by Coates [5] and Mumtaz [6].

All of these studies are anecdotal and published as letters in the journal Anaesthesia [4–6]. One of the co-authors in this study (NR) was involved with several firsts to methodically evaluate the CSE technique in controlled trials including (i) CSE versus epidural for cesarean section in 1988 [7,8], (ii) CSE versus epidural and spinal for labor pain in 1991 [9], (iii) CSE versus spinal and epidural for hip and knee arthroplasty in 1993 [10], and (iv) epiduroscopic studies to assess the risk of epidural catheter migration through the dural hole made by a spinal needle in 1995 [11]. This author also introduced the concept of sequential CSE in 1986 [7,12–14] and evaluated the unique opportunity presented by CSE to compare the analgesic potency of intrathecal versus epidural morphine for postoperative analgesia [10].

CSE involves the administration of local anesthetic into the subarachnoid space to achieve spinal anesthesia followed by placement of an epidural catheter into the epidural space as part of the same procedure. The advantage of CSE is that the neuraxial block is achieved rapidly by the spinal component while the epidural catheter allows modification of the block and also its extension for achieving prolonged analgesia or anesthesia. CSE can combine the best features of spinal block (rapid onset, profound blockade, low dose of local anesthetic) and epidural block (titratable levels, ability to prolong block effects indefinitely). At the same time, CSE avoids or decreases their disadvantages, i.e., spinal (single shot method, severe hemodynamic effects, unpredictable level of blockade) and epidural (missed segments, incomplete motor block, poor sacral spread, local anesthetic toxicity). A literature review showed CSE to be as safe as a spinal or an epidural alone [15]. The third National Audit Project of the Royal College of Anaesthetists on the incidence of major complications following central neuraxial block reassured anesthetists that central blocks are safe and the incidence of serious injury and death was less than 2 per 100,000 [16]. This incidence was slightly higher in non-obstetric patients receiving a CSE. However, CSEs in obstetrics were not found associated with a significant increase in complications.

Indications for CSE

CSE has been used in a wide variety of non-obstetric surgical procedures including orthopedic, urological, vascular, gynecological, and general surgical procedures. It is becoming increasingly popular in obstetric anesthesia both as a method of providing pain relief in labor and as an anesthesia technique for cesarean section. In obstetrics, CSE is used frequently but its use is variable across countries and institutions. In some areas, it is used infrequently and for specific indications only, whilst in other institutions it is the primary and standard technique for labor analgesia and anesthesia for C-section. A 2004 UK survey showed that 65% of consultant anesthetists used CSE [14], whilst a 2022 survey from the US showed that in 43% of teaching institutions, CSE was the standard technique of labor analgesia [17].

There are several reports in the literature on the use of CSE in high-risk patients undergoing obstetric, geriatric, and neonatal surgery [18] as well as in patients undergoing cesarean section who have severe co-morbidities such as osteogenesis imperfecta, thoracic scoliosis, cardiomyopathy, tetralogy of Fallot, Holt-Oram syndrome, etc. [19] CSE is safe and effective also in high-risk geriatric patients undergoing hip fracture surgery [20]. A recent report from Finland evaluating regional anesthesia (RA) techniques (pudendal, paracervical, epidural, spinal, CSE) for labor analgesia in obese and grossly obese parturients over a 15-year period (n = 744,723) concluded that spinal and CSE techniques increased the most over the years [21].

In a case series, a thoracic CSE was successfully used in patients with cardiovascular and/or pulmonary problems. The technique was used for abdominal surgeries (cholecystectomy, bowel surgery, vascular surgery); because of very low doses of local anesthetics, there was no block of the lower extremity [22]. However, spinal anesthesia above the L2-L3 level should be avoided because of the potential risks of permanent neurologic damage [23]. Only when a clear risk/benefit analysis is done exceptional high placement of the spinal should be considered.

The above-mentioned survey of English obstetric consultant anaesthesiologists (n = 208) showed that more than half of the respondents also used CSE for non-obstetric surgeries. The main reasons for using CSE were long-duration surgery, provision of postoperative analgesia, the flexibility of technique, and speed of onset of the block [24].

In particular, CSE has become an important indication for cesarean section. In no other area, the change from general anesthesia to regional anesthesia has been more marked than that in cesarean section. In our institution (as in most others), a parturient rarely prefers general anesthesia for her cesarean delivery.

A descriptive CSE literature review 20 years ago, based on nearly 60 papers and several reviews and editorials, showed that the most common indications were obstetric anesthesia and analgesia. It was also used for orthopedic, trauma, general, vascular, and gynecological surgery as well as in pediatric surgery. CSE is considered to be the technique of choice for determining minimum intrathecal drug doses and for comparing appropriate doses for spinal and epidural drugs [25]. More than any other technique the presence of an epidural catheter as a backup allows obstetric anaesthesiologists to fine-tune the limits to which one can go to reduce dosages of spinal local anesthetics (and adding opioids) that allow parturients to ambulate and for c-section patients to be mobilized early as part of enhanced recovery after surgery (ERAS) protocols [24].

Use of CSE in obstetrics

CSE for labour analgesia

Since Abouleish et al. [9] introduced CSE for labor analgesia, it has become a standard technique of labor analgesia initiation. As mentioned, uptake is variable but it is increasingly popular because of its rapid onset, reduced frequency of breakthrough pain, and more reliable epidural catheters when compared to conventional epidural analgesia initiation and maintenance [26]. Furthermore, CSE reduces local anesthetic consumption by 25% and also reduces motor block, especially in prolonged labors [27,28].

Theoretically, CSE can increase (because of the breach of the dura) the risk of meningitis and post-dural puncture headache (PDPH). However, to our knowledge, no study has identified yet a higher chance of meningitis. Many studies have compared CSE with epidural analgesia and could not demonstrate a difference in the incidence and severity of PDPH [29]. CSE carries a higher risk of mild maternal hypotension, especially when the parturient is placed supine with left lateral tilt [30]. However, when patients are kept in the full left lateral position the chance of hypotension is certainly decreased.

The most important side-effect associated with CSE is an increased incidence of fetal heart rate (FHR) abnormalities. After any form of labor analgesia initiation, FHR changes can occur. However, several studies have documented that CSE carries a higher risk of FHR changes [30]. This is especially the case when high-dose lipophilic opioids are administered intrathecally and when the parturient is in advanced labor with high-dose oxytocin stimulation. When changes in FHR occur, these can be treated rapidly and easily by administering fluids, ephedrine, oxygen, and in some cases active tocolysis. Cesarean delivery is not required usually. The mechanism of FHR changes is a combination of mild maternal hypotension and uterine hyperactivity due to a temporary imbalance between norepinephrine (uterine stimulant) and epinephrine (tocolytic). This imbalance occurs as a result of rapid analgesia, reductions in stress hormone release, and a longer half-life of norepinephrine when compared to epinephrine. FHR changes can be prevented by a temporary reduction or temporary stopping of exogenous oxytocin.

Care must be taken when performing a CSE to introduce the spinal needle below the L2-L3 interspace. Indeed, spinal punctures above the L2 interspace carry the risk of accidental spinal needle introduction into the spinal cord which can cause permanent neurologic deficit [23].

Unfortunately, due to anatomical changes occurring in pregnancy, landmark identification of the L3-L4 interspace is difficult. Several MRI and ultrasound studies have demonstrated that >50% of anesthesiologists are wrong when they identify the L3-L4 interspace and more importantly the majority of anesthesiologists perform the puncture at a higher level than they assume. Therefore, the golden rule should be “go as low as possible” when you do CSE labor analgesia.

The initial spinal dose is a combination of a long-acting local anesthetic such as bupivacaine (2.0–3.5 mg) or ropivacaine (3.5–4.5 mg) and a lipophilic opioid such as fentanyl (1–3 mcg/mL) or sufentanil (0.3–0.75 mcg/mL). Other adjuvants have been tested but they produce significant side effects when given intrathecally. Clonidine causes severe hypotension which can be prolonged. Neostigmine causes nausea and vomiting.

CSE for C-section anesthesia

Worldwide single-shot spinal anesthesia (SSS) is the preferred technique for neuraxial anesthesia for C-sections. A recent systematic review of 54 RCTs ($n = 3497$) evaluated the prevalence of intra-operative inadequate analgesia in patients undergoing elective cesarean section. The overall prevalence of requirement of supplemental analgesia or anesthesia was 14.6% but a big difference between the techniques was observed; it was 0.06% with general anesthesia, 10.2% with spinal/CSE, and 30.3% with epidural anesthesia [31].

Intrathecal (hyperbaric) bupivacaine combined with lipophilic opioids is given for intraoperative anesthesia in a dose of 10–15 mg. Rapid onset is combined with a profound anesthetic block. However, the duration of anesthetic conditions is limited to 75–105 min. SSS causes significant hypotension in pregnant women. Hypotension can be prevented or treated by giving vasopressors when performing the spinal technique.

An alternative method to reduce hypotension after SSS is to reduce the local anesthetic dose to below 9 mg. There is overwhelming evidence that this method reduces maternal hypotension [32]. However, because the dose of bupivacaine is low, the duration of good anesthetic conditions is limited. Arzola reported that CSE was associated with more breakthrough pain [33]. However, they recorded every epidural top-up as “breakthrough pain” whilst we believe that an epidural top-up is an integral part of the CSE technique. Indeed, after 45 min of anesthesia, usually a low spinal dose (<9 mg) starts to wear off and an epidural bolus is required when surgery is prolonged beyond the 45-min mark (see Table 1).

Table 1
Advantages and disadvantages of CSE.

Advantages of CSE	Rapid onset of block Good analgesia More reliable epidural catheters. Replacement rate and interventions for breakthrough pain reduced. Reduced epidural catheter dislocation and replacement Less motor block Less local anesthetic consumption
Disadvantages	PDPH Risk of neurologic injury Meningitis Maternal Hypotension FHR abnormalities

Table 2
Indications for CSE in obstetric anesthesia*.

Labor pain
➢ Need for rapid pain relief
➢ Resiting of epidural catheter
➢ High epidural failure risk
➢ Obese patient (first choice)
➢ Cardiac parturients
➢ High risk of cesarean section
➢ Anticipated difficult airway
Cesarean section
➢ All cesarean deliveries in spite of a higher cost and time of performance, compared with spinal technique

Source: Gausch E, Wenk M. 2020 (ref 34).

A recent editorial [34] on current challenges in obstetric anesthesia listed the current indications of CSE in labor and cesarean section as shown in Table 2.

Dural puncture epidural technique (DPE) in obstetrics

The DPE was first described by Suzuki et al. in a cohort of abdominal surgery patients [35]. As with CSE, the epidural space is identified with the loss of resistance technique. The dura is then punctured with a spinal needle, but no intrathecal medication is administered. It is hypothesized that medication administered in the epidural space will move via the dural puncture into the intrathecal space allowing for faster onset of analgesia, better sacral spread, less unilateral block, and lower rates of motor block compared to a conventional epidural. As no intrathecal medication is given, it is expected that the unwanted side effects such as uterine hypertonus, fetal bradycardia, maternal hypotension, and pruritis are minimized. As the dura is punctured and CSF visualized, confirmation of midline placement is made and a test dose can be administered to rule out an intrathecal or intravascular catheter if desired.

Thus, the DPE technique was proposed to offer the “best of both worlds” providing most of the benefits of the CSE technique without the adverse side effects, but a faster and more reliable block when compared to epidurals.

Three reviews conducted in 2018 and 2019 by Layera et al. [36], Gunaydin et al. [37], and Heesen et al. [38], respectively, could not provide clear evidence of benefit of the DPE technique. However, DPE offered a more reliable benefit if a 25G spinal needle was used as opposed to the smaller 26G and 27G needles.

Three additional randomized control trials have been conducted since 2019, but again heterogeneous results were found.

The authors believe that DPE is a potential initiation method that can be used in certain circumstances (early insertion of a neuraxial block in cases of preeclampsia for instance). However, currently, it cannot be recommended as a routine, standard technique for all.

CSE - technique modifications

Needle-through-needle technique

This is the most widely used technique [15]. The UK survey showed that 73% of consultants used the needle-through-needle technique [24]. After identification of epidural space by an epidural needle, a fine gauge (25 or preferably 27 G) spinal needle is introduced into the subarachnoid space, and spinal anesthesia is performed in the usual manner by injecting a local anesthetic. After removal of the spinal needle, an epidural catheter is introduced in the epidural space also in the usual manner. Epidural needles with a hole in the curvature 'backeye' allow the epidural catheter to be inserted away from the dural puncture site to reduce the risk of subarachnoid placement of the epidural catheter. Other developments include the use of spinal needles which lock into epidural needles after dural puncture. This mitigates the risk of failure of the spinal block due to spinal needle displacement during connection of syringe and administration of a drug. However, the success rates of the 'locking' versus 'non-locking' needles seem to be similar (98–99%) [15]. A modification of the technique is to perform the epidural part first with the catheter in the epidural space followed by the spinal block to preserve the warning sign (paraesthesia) of a misplaced epidural needle or catheter. The downside is the possible risk of catheter damage by a spinal needle.

Separate needle technique

In this technique, two separate needles are used to perform the spinal and epidural components of CSE. Both needles can be introduced at the same intervertebral space or, as is more common at two interspaces. The main advantage of performing the spinal first is the rapid onset of analgesia. Comparative studies have shown higher failure rates with the needle-through-needle technique mainly due to problems with the spinal component [15].

Sequential CSE or EVE?

The sequential CSE approach incorporates the use of local anesthetic (LA), normal saline, or opioid into epidural space after intrathecal injection of LA. Thus, a low subarachnoid block can be extended significantly in the cephalad direction by an epidural 'top up' given within 5–10 min of subarachnoid administration of LA. This modification of the CSE technique using LA epidural top-up was first described by Rawal and termed low-dose sequential CSE [7,13,14]. However, with time, the term EVE has grown to be associated with the injection of saline rather than local anesthetics. Some users now choose a deliberately low intrathecal dose with the expectation of extending block height with epidural saline or drugs before surgery.

The sequential CSE technique is performed as follows:

1st stage - patient in sitting position (C-section): After identification of the epidural space by epidural needle (Tuohy 18G) a pencil-point 27G spinal needle is introduced through it and a spinal block is performed with an intentionally low dose of local anesthetic (hyperbaric 0.5% bupivacaine 1.5 ± 0.2 ml) and the patient is positioned in supine position with left lateral tilt.

2nd **stage, the patient is in the left lateral position.** Block level is checked frequently while waiting for a spinal block to be fixed. If necessary, the block is raised to the desired level by administration of epidural top-ups (1.5–2 ml 0.5% bupivacaine for every unblocked segment).

This technique was originally employed for cesarean section to keep the dose of a local anesthetic to the lowest level possible. The slow incremental administration of epidural LA markedly reduces the risk of severe, precipitous hypotension due to less sympathetic block which allows the body's compensatory mechanisms to come into play [7,12,39]. This has been confirmed by more recent studies [14,40,41], Sequential CSE is particularly useful in high-risk parturients. During elective CS, the dose of LA is one of the factors that determine the degree and severity of spinal anesthesia-induced hypotension (SIH). Estimates of the incidence of SIH are between 15% and 33% [40]. Lowering the dose of spinal local anesthetic combined with the administration of opioids has been successful in mitigating SIH as well as other maternal and fetal complications [40]. To enhance the efficacy of low-dose LA, the placement of an epidural catheter as part of CSE allows for a 'top-up' dose of LA or opioids. The disadvantage of sequential CSE is that it takes about 15–20 min longer to establish and therefore is not appropriate for emergency C-section.

In a systematic review of 18 RCTs, sequential CSE ('EVE with lLA') showed significantly decreased requirements of intraoperative analgesic supplementation and faster motor recovery. Sequential CSE has been affirmed as a method to decrease intraoperative opioid requirements compared to conventional single-shot spinal or conventional CSE. Significantly improved motor recovery time facilitates better results in ERAS programs [40].

The sequential CSE technique has also been studied in non-obstetric patients. In a controlled trial of 50 patients undergoing lower abdominal surgery (level of block extended to T6 by injection of fractionated dose (1.5–2 ml per unblocked segment) of 0.5% bupivacaine into epidural catheter depending on the need). This CSE technique was compared with spinal anesthesia. The quality of analgesia and onset of action were similar but CSE was associated with better hemodynamic stability with the added advantage of prolongation of block for postoperative analgesia. In this study, the authors used the double space technique because the equipment for a single segment was considered too expensive in the author's country [41].

Published narrative reviews have highlighted several benefits of EVE. In addition to a higher level of sensory block, it allows the use of lower doses of LA. In a study of non-obstetric patients, a minimum effective dose of plain bupivacaine was reduced [42]. The lower dose of intrathecal la decreased the incidence of hypotension and speeded motor recovery after the procedure [14,42].

Many factors affect EVE. They include timing, the volume of saline, baricity of LA, position during or after spinal, and obstetric versus non-obstetric patients. EVE is a time-dependent phenomenon with maximum benefit if performed early. Although there are other proposed mechanisms of action, the widely accepted mechanism of action is intrathecal compression of subarachnoid space by saline or LA used for epidural top-up due to the volume effect which promotes cephalad displacement of LA in CSF. Takiguchi et al. using myelography in human volunteers demonstrated that the contrast medium in subarachnoid space was narrowed due to the volume effect [43]. Another accepted mechanism of EVE is the transfer of LA from the spinal needle hole and diffusion of LA into subarachnoid space. Both the volume and LA effect of EVE during CSE were examined in earlier studies in non-obstetric cases [43,44]. Stienstra et al. found that EVE with both normal saline and LA increased the sensory block height [44]. Furthermore, Takiguchi et al. reported that injecting 10 ml of saline into the epidural space immediately after the subarachnoid block raised the level of sensory blockade [43].

Complications of CSE

The possible risks of CSE can be due to the technique or due to the drugs administered in subarachnoid and/or epidural space. These include failure of a block, migration of epidural catheter into subarachnoid space, damage to spinal needle or epidural catheter, neurological complications, PDPH, and infection (meningitis, abscess).

1. Catheter migration into subarachnoid space

The risk of epidural catheter migration into the subarachnoid space through the hole in the dura created by a spinal needle is greater with the needle-through-needle technique. This risk is increased while, rather than after, the CSE technique is being performed. However, the reported risk of this complication is low.

Epidural catheter migration into the subarachnoid space is potentially very serious because failure to recognize catheter misplacement and administration of the usual epidural dose could result in total spinal anesthesia. However, there are very few reports of this complication with CSE. The possibility of subarachnoid or intravenous placement of epidural catheter exists with any epidural catheter and the danger of massive intrathecal dose is not unique to CSE. Total spinal blocks are an acknowledged complication of 'top ups' of previously normally functioning catheters [45]. There is no evidence that this risk is greater with CSE. Our epiduroscopic study of catheter migration in fresh cadavers showed that it was impossible to force a 16 G or 18G epidural catheter through a dural hole made by a 25 G spinal needle [11].

2. Subarachnoid spread of epidurally administered drugs

Although a higher block level can be expected due to some subarachnoid spread of epidurally administered LA, it does not appear to be clinically relevant. The transdural drug transport of dangerously large quantities of subsequently administered epidural drugs reaching subarachnoid space has not been reported in literature [15].

3. Neurologic damage

There is no evidence that the risks are greater than those reported after conventional spinal or epidural anesthesia. A retrospective survey showed an estimated rate of 114 per 1000, the vast majority are minor with no long-term effects [15]. The 2009 National Audit Project (NAP) 3 report noted an increased risk of neurologic damage with CSE in the non-obstetric population [16].

4. PDPH

PDPH can occur after epidural anesthesia and analgesia due to an accidental dural puncture and also after spinal anesthesia due to the intentional perforation of the dura. Theoretically, the risk of PDPH is increased with a combination of both techniques. However, CSE with small gauge non-cutting spinal needles does not increase the risk of PDPH [29].

5. Infection

The protective barrier provided by the dura is intentionally breached with the spinal needle followed by the introduction of an epidural catheter which is a potential source of infection (role of duration of treatment). However, there is no evidence that CSE is associated with a higher risk than epidurals or spinal alone [14]. In general, serious infective complications are rare after CSE [15,39,45].

Conclusions

CSE is a well-established technique in obstetric anesthesia and analgesia. The administration of intrathecal opioids or a combination of intrathecal local anesthetic and opioids produces rapid and effective analgesia during labor. Side effects such as FHR abnormalities can easily be prevented if the technique is performed correctly. Using the CSE technique during a C-section allows for a reduced intrathecal dose of bupivacaine, thereby reducing the incidence and severity of hypotension. A novel form of CSE, the DPE technique, is currently under investigation but cannot yet be recommended as a routine technique.

CSE is also used in a wide variety of non-obstetric surgical procedures including orthopedic, vascular, gynecological, urological, and general surgical procedures.

Practice points

- CSE for labor analgesia produces rapid analgesia with excellent pain relief and a reduced incidence of breakthrough pain and a reduced need for epidural catheter replacement.
- CSE for labor analgesia can induce FHR abnormalities.
- CSE must be inserted lower than the L2-L3 interspace.
- CSE for C-section allows for reduced doses of local anesthetic. This reduces the incidence and severity of hypotension.
- However, low-dose CSE has a limited duration of action and therefore epidural top-ups are often required when the C-section is prolonged beyond 45 min.
- In the non-obstetric patient population too, the combination of rapidity, density, and reliability of spinal block with the flexibility of catheter epidural technique to extend the duration of anesthesia and analgesia has many benefits in a wide range of surgical procedures.

Research agenda

- The role of transfer of epidurally administered drugs through the dural hole made by the spinal needle needs to be evaluated further.
- Further study is required to evaluate the DPE technique in obstetrics.
- Studies comparing CSE with an epidural for labor pain and with a spinal for a C-section are necessary to establish the best neuraxial technique in obstetrics in the future.

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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