COMBINED SPINAL-EPIDURAL ANAESTHESIA TECHNIQUES.......... A REVIEW

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SUMMARY

Combined Spinal Epidural (CSE) anaesthesia commands a unique place among the various techniques used for neuraxial blockade. In this article we delve into the history of CSE and try to enumerate the types of specialised needles devised for this technique. The spinal needles that are, and in the future may well be associated with this technique are also discussed. The methods used to locate the epidural space have been researched exhaustively and an attempt has been made to classify the various options available for CSE. Controversial aspects such as the preferred approach, catheter threading prior to or after subarachnoid block and the need for test dosing have also been addressed.

Keywords : Combined Spinal Epidural, CSE, Tuohy Needle, Spinal needle, Catheter.

Introduction

Among the various techniques used for neuraxial blockade, CSE commands a unique place. The singularity lies in its ability to combine the rapidity, density, and reliability of the subarachnoid block with the flexibility of continuous epidural block to titrate a desired sensory level, vary the intensity of the block, control the duration of anaesthesia, and deliver postoperative analgesia. Of late, this procedure has come back in a big way, the fact justified by its use extended to paediatric and even infant laparotomies, apart from its use in orthopedic surgery, obstetrics, very old patients and in other high-risk patients.1 Although at first sight the CSE technique appears to be more complicated than either epidural or spinal block, intrathecal drug administration and placement of the epidural catheter are both facilitated by the various modifications of the combined spinal-epidural technique.1 2 In this article we try to follow the evolution and also summarise the various developments in this technique described by various authors over the years.

History

Leafing through the archives of anaesthesia, we find that CSE was first described in 1937 by Soresi3, who used the "episubdural" technique by first injecting a dose of local anesthetic epidurally and, after advancing the needle inside the dural cavity, injecting the spinal dose. Curelaru4 performed the first combined spinal anaesthesia and catheter-based epidural anaesthesia in 1979. He introduced an epidural catheter through a Tuohy needle, administered a test dose, and then performed a traditional dural puncture 1–2 lumbar segments distally using a 26-gauge spinal needle. CSE was performed in 1982 on a single spinal segment for lower limb surgery by Coates5 and Mumtaz6 et al. Epidural anaesthesia was performed using a 16-gauge Tuohy needle, after which a 25-to 26-gauge spinal needle, approximately 1 cm longer than the epidural needle, was introduced with the Tuohy needle as introducer. After the injection of local anesthetic, the spinal needle was withdrawn and the epidural catheter inserted. In 1986, Rawal described a single segment sequential CSE for caesarean delivery. (see below "Sequential CSE"). Over the years, a variety of spinal, epidural and specialised combined spinal-epidural needles have been devised and a myriad of techniques described to refine this procedure.

Classification

The various options in CSE can be classified broadly according to the number of interspaces used for performing the procedure (table 1). If both the epidural and the spinal punctures are performed in the same interspace it is called single segment technique (SST) or single interspace CSE technique and the others are named double segment techniques (DST) or double interspace CSE technique. These can be further classified according to the type of needle used and the approach.

Single and double segment techniques

The reduced number of skin punctures in SST decreases the incidence of patient discomfort, trauma, pain, infection at puncture sites, epidural venous puncture and formation of hematomas.1 The use of an epidural needle as an introducer for the spinal needle lessens the likelihood of contamination of the spinal needle with skin-borne...
However, no quantitative studies have been performed to confirm these assumptions. In DST, there is always a theoretical possibility of damaging the epidural catheter with the spinal needle if the catheter is threaded before subarachnoid block. The advantage of DST is that it does not require specialised CSE needles that are more expensive than the usual epidural and spinal needles.

### Table 1: Classification of CSE Techniques

<table>
<thead>
<tr>
<th>Category</th>
<th>Technique Details</th>
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<tbody>
<tr>
<td>Double Segment, Median Approach</td>
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<tr>
<td>Paramedian Approach</td>
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Each of these can be performed with or without epidural and/or spinal catheters.

### Needles

#### Single Lumen Epidural Needles (Needle-Through-Needle technique)

1. Epidural Needle with Single Aperture: This most commonly used set consists of a conventional 16-18 gauge epidural needle (Fig. 1A) to locate the epidural space. A spinal needle is then introduced through the epidural needle exit through the Huber eye and proceed to puncture the dural wall and enter the subarachnoid space.

2. CSE Needle with Additional Aperture (Huber and Hanaoka Needles): This is basically an epidural needle with an additional aperture (‘back eye’) situated at the end of the longitudinal axis.8,9 (Fig. 1B)

The usual technique is used for identification of the epidural space. The spinal needle is then introduced through the proximal port of the epidural needle to exit at the ‘back eye’ and after dural puncture and drug administration the spinal needle is withdrawn and the catheter inserted. The larger diameter of the catheter causes it to pass through the usual Huber opening. These modified needles function as a suitable introducer for even the thinnest spinal needle, as kinking and friction in the Huber eye of the epidural needle is avoided. Advancing the spinal needle through the “back eye” may offer a more distinct sensation of dural puncture.10 To accomplish proper passage through the “back eye,” however, the distal end of the spinal needle must face the same way as the Huber opening of the epidural needle; otherwise the spinal needle may pass through the Huber eye.11 But a traditional insertion of the epidural needle with the Huber eye facing cephalad will then cause the cutting bevel of the spinal needle to cut the dural fibers perpendicular to its alignment, which may increase the risk of postdural puncture headache.12 With the needle through needle technique, there is a concern about the tip of the spinal needle scraping the inner wall of the epidural needle and thereby leading to deposition of metal particles in the epidural and/or subarachnoid spaces and possible, subsequent neurological sequelae.13 However, studies by Herman et al14 failed to find any evidence of additional metal particles produced by the needle-through-needle technique and puts these doubts to rest. The risk of damage to the bevel of the spinal needle has been circumvented by the introduction of a plastic sleeve for the spinal needle by the Espocan® system.1 The plastic sleeve keeps the spinal needle centrally in the epidural needle and guides it through the back eye.

In this technique, the spinal needle is in contact with only dura and the epidural needle, which may increase the risk of displacement of the spinal needle at the time of...
syringe connection, aspiration of CSF or injection of local anaesthetic.1 A study conducted by Tanaka N and co-workers15 and Hoffmann et al16 clearly demonstrated that the lockable CSE provided safe and stable conditions and a good success rate of subarachnoid block. But the feel of the “dural click” was diminished when lockable CSE was used.

Double-Lumen Needles: (Needle-Beside-Needle technique)

In this technique, an epidural needle and spinal needle are introduced through separate lumens or barrels. The spinal needle guide may or may not be attached to the epidural needle.

Separate Needle

In the technique described by Eldor and Olshwang, the epidural needle is first placed in the epidural space by the usual method followed by the introduction of the spinal needle beside the epidural needle to perform the subarachnoid puncture.17

A recent article by Cook described a variation from this sequence by first locating the spinal needle in the subarachnoid space and observing the free flow of CSF. The stylet of the spinal needle is then replaced. The epidural needle is then introduced via the median or paramedian approach and catheter threaded, following which the intrathecal drug is administered.18

Attached Needle

A parallel tube is attached to the epidural needle, which acts as the introducer for the spinal needle. The parallel tube may be either bent at the proximal end or straight through out. The Eldor Needle (Fig. 1C) has a straight tube attached while the Eldor, Coombs and Torrieri Needle (Fig. 1D) has a bent spinal needle attached.7,19 The T-A needle is a further modification where both the needles are welded together and the distal ends of the needles make a common tip. The epidural needle points cephalad and the spinal needle points caudad.20 The more recently introduced E-SP needle has a needle wall configuration that is “over-under” rather than parallel.1

Spinal Needles

The gauge and type of the spinal needle influences the success of the procedure and the incidence of outcome. The use of smaller gauge needles and ones with a conical tip reduces the incidence of post dural puncture headache.21,22 Lipov23 et al. demonstrated that the axial force needed to deform the Sprotte needle tip was less than that needed for the Whitacre and Quincke needles of similar size. The larger distal side port of the Sprotte needle, as well as its greater distance from the tip, may account for the slightly greater deflection observed with Sprotte needles compared to Whitacre needles. (Fig. 2)

![Fig. 2 : Tip of different types of spinal needles. A: Sprotte, B: Whitacre, C: modified pencil-point, D: ball pen, E: double-hole pencil-point, F: Quincke, G: Atraucan.](image)

Newer needles have been designed to improve efficacy. The Atraucan needle has a double bevel with the distal cutting bevel making a cutting incision in the dura. The second part of this needle dilates this incision rather than cutting through the fibres leaving only a small hole in the dura. The sharp tip however is prone to damage.24 A new pencil-point spinal needle described is the double-hole pencil-point (DHPP) spinal needle, and is composed of a blunt ogival tip and two circular holes opposing each other just proximal to the tip. The area of the two windows is almost the same as of the single holed Sprotte needle’s area, which enables more rapid CSF reflux. The anesthetic solution injection spreads through both windows. This allows a more diffuse anesthetic distribution and less anesthetic solution dosage. The DHPP spinal needle allows anesthetic solution injection even when a tissue fragment obstructs one of the holes. More recently, the ball pen needles have been marketed in France. The tip of this needle is actually the tip of the stylet leaving a hollow cannula when the stylet is removed. The proposed advantages of this needle are that the tip of the needle is always completely in the subarachnoid space and on removal of the stylet there is no needle tip projecting beyond the orifice causing damage to the neurological tissue. There is no mechanical weakening at the tip caused by the presence of a lateral orifice. The open end of the needle allows laminar flow of cerebrospinal fluid, which results in faster identification of the subarachnoid space.24

Optimal Length of the Spinal Needle Beyond the Epidural Needle Tip

The distance from the tip of the epidural needle to the posterior wall of the dural sac in the midline varies considerably among patients (0.3-1.03 cm).25,26 Further, the
The anteroposterior diameter of the dural sac varies considerably during flexion and extension of the spinal column. At L3-L4, the diameter increases from a range of 9-20 mm in extension to a range of 11-25 mm in flexion.27 Additionally, these findings are only valid when the epidural puncture is performed in midline. This is because the dural sac is triangular with its base resting on the vertebral body and the triangle top points posteriorly to ligamentum flavum.28 A minimum of 13 mm length of the spinal needle protrusion beyond the epidural needle tip is recommended for the CSE sets for a reasonably high success rate.10 Also, because of needle design, the length of protrusion for needles with side orifice should be greater than that for end orifice needles.29

**Techniques**

The first neuraxial blockade performed by Corning must have been an epidural rather than a spinal block.30 The earlier methods to identify the epidural space were the feel and hear method of Pages, positive plunger pressure by Dogliotti, “hanging drop” method by Gutierrez and the balloon deflation technique by Macintosh and Oxford.31 Most of these techniques were based on the concept of “negative” pressure in the extradural space. However, the experiments of Urayama and Shah32 showed that 77% of the lumbar pressure in the extradural space. However, the experiments of these techniques were based on the concept of “negative” pressure in the extradural space. However, the experiments of Urayama and Shah32 showed that 77% of the lumbar cerebrospinal fluid pulse wave, which is directly transmitted to the extradural space as an extradural pressure wave originates in the vascular system (arteries and veins), and not in the brain. So, any rise in the blood pressure, which is not an infrequent observation during epidural needle insertion, can give a concomitant rise in the extradural pressure with the loss of the “negative” pressure in the extradural space and “unreliable” hanging drop and balloon indicator techniques. Many feel the loss of resistance to saline or demonstration of a free flow of the saline column is a superior method for properly identifying the epidural space. However, when administering CSE, the use of air has been advocated so that there is no confusion that the fluid returning is CSF when the spinal needle is subsequently placed. These techniques have the disadvantage of identifying only the epidural space and not the subarachnoid space. Kopacz et al34 describes a further modification of this technique which may increase the success rate and ease with which it is performed. The modification described allows the continued use of saline for loss of resistance using an epidural needle with a transparent hub. First, close attention is paid to the location of the saline meniscus left within the epidural hub after demonstrating the loss of resistance using saline. If a loss of resistance to air technique is used, a small amount of saline can be introduced to create this meniscus. The spinal needle is advanced in the usual fashion until it is felt to exit the epidural needle. As the spinal needle is advanced further to contact and indent the dura, the tenting of the dura generates a negative pressure within the epidural space, causing the meniscus to be drawn in. This is similar to what is seen when performing the “hanging drop” technique of identifying the epidural space. As the spinal needle is advanced further, the dura is punctured and the meniscus returns to near its original location as the pressure within the epidural space returns to baseline. Finally, CSF is observed to flow into the spinal needle to ultimately drip from its hub. The point at which the meniscus starts to advance is dependent on the dimensions of each particular patient's epidural space and to what distance the needle has traversed the epidural space. This phenomenon is reported to be a very specific indicator of needle location and is most easily seen when a Whitacre spinal needle is used. When a Quincke or Sprotte needle is used, the movements of the meniscus may occur so suddenly that often only a “pop” or “splash” of the fluid is detected, or no movement is seen at all. These observations agree with the studies showing that more force is required to penetrate the dura with a Whitacre needle compared to a Quincke needle.35

The ‘membrane in syringe’ technique is, in principle, a modification of the loss of resistance technique for identifying the epidural space.36 A novel method to identify the epidural space using an acoustic device was described by Jacob S and Tierney E.37 The traditional loss of resistance technique is combined with amplification of the sound made by the epidural needle as it traverses the interspinous ligament and the ligamentum flavum and then enters the epidural space. Lechner TJ and associates38 described a variant of the previous method. This consisted of translating the pressure generated during the epidural puncture procedure into a corresponding acoustic signal. Both these methods combine the loss of resistance techniques with a newer approach to improve the success rate by giving an early warning of entry into epidural space. In addition, these can be excellent teaching aids for beginners.

A still newer method to locate the epidural space using real-time ultrasonic guidance has been described by Grau T and colleagues.39 Epidural space localization has also been reported by using an electronic device known as Episensor but with limited success.40

**Sequential CSE Technique**

Rawal first described this variation of the standard CSE technique.7 The spinal block is performed in the sitting position and a low dose of hyperbaric bupivacaine is administered to achieve a S5 to T8-T9 block. The patient is placed supine with a left lateral tilt. When the spinal block is “fixed” it is extended to T4 by injecting fractionated doses of local anaestheti into the epidural catheter.
Two Catheter CSE Technique

A technique of providing CSE anaesthesia using both spinal and epidural catheters in the same and different interspace was described by Dahl et al and Vercauteren et al respectively. The main advantage was the possibility of titrating the intrathecal dose of the local anaesthetic to the desired dermatomal level and to test the correct position of epidural catheter before injecting the drugs. Because of the requirement of a large diameter spinal needle (22-gauge), the risk of catheter penetration may be high; knotting of the catheters is also a theoretical risk.

Approach

Blomberg et al, Gaynor A and Hatfalvi B compared the midline and paramedian approaches for lumbar epidural block and concluded that the paramedian approach was superior due to the following reasons.

1. Easier to locate the epidural space and reduced incidence of technical and catheter-related problems - extreme flexion of the back to open up the interlaminar space is not required;
2. Reduced risk of trauma to the epidural veins and lower incidence of epidural vein cannulation;
3. Easier catheter insertion - the needle is angulated substantially more cephalad resulting in less “tenting” of the dura and a straighter catheter path;
4. Lower incidence of dural puncture;
5. Less paresthesia on catheter insertion and fewer traumas to the ligaments of the back, with fewer complaints of postpartum backache;

Muranaka K and colleagues concluded that though the paramedian approach may be extremely useful for patients with a midline scar or for those with a rigid spine, it requires a longer spinal needle "compared to the median approach.

Rotation of Epidural Needle

Rotation of the epidural needle by 180° between administration of the subarachnoid injection and threading of the epidural catheter had been advocated so that the site of the dural puncture is away from the point at which the catheter impinges. This was presumed to decrease the chance of subarachnoid placement of the catheter. But, in fact, rotation of the epidural needle increased the chance of inadvertent dural tear or puncture and subarachnoid catheter placement. This practice has hence been condemned.

Catheter

Holmström et al states that the distribution of fat, rather than any dorso median connective tissue band, influences the course of epidural catheter in epidural space. Single-holed, open-end (uniport) and multiple lateral holed, closed-end (multiport) epidural catheters are commonly used; however, the risks and benefits associated with each are controversial. Advantages cited in favor of the blunt-tipped multiport epidural catheter include a reduced likelihood of intravenous (IV) cannulation, since the catheter tip is less likely to traumatize an epidural vein during insertion, and a reduced incidence of inadequate analgesia, since local anesthetic distribution may be enhanced by the total separation of the three lateral ports. In contrast, multiport epidural catheters have the theoretical disadvantage of multicompartment placement when at least one port is intrathecal, subdural, or IV, while the other port lies within the epidural space. Multicompartment placement increases the risk of high spinal blockade or local anesthetic toxicity when local anesthetics are rapidly administered. But D’Angelo et al found that multiport epidural catheters were associated with less inadequate analgesia and required manipulation less often than uniport epidural catheters. A newer version of epidural catheter is the combined end-multiple lateral hole (CEMLH) catheter. It has 7 holes within its 1.5 cm head: One at the tip; the first 3 lateral holes are arranged circumferentially at 1 mm from each other; the other 3 holes have a 4 mm distance from one to the other.

Beilin et al found that women in labor, who had multi-orifice epidural catheters threaded 5 cm into the epidural space through a cranially directed epidural needle orifice at the L2-3 or L3-4 interspace, had the highest incidence of successful analgesia with 0.25% bupivacaine, as compared to women with catheters threaded 3 or 7 cm into the epidural space. The studies of Holmström et al indicate that the risk of epidural catheter migration through the dural hole during uncomplicated combined spinal epidural block is very small.

Among the blind end catheters the softer tip ones were least likely to cause transient paresthesias during epidural catheter placement but the wire reinforced ones were easier to insert and maneuver. Threading of the epidural catheter may at times be a tricky affair and consume a considerable amount of time. There are two schools of thought regarding whether the catheter should be threaded before or after the subarachnoid block. If catheter insertion is attempted after spinal drug administration,

1. This may lead to the spinal drug “fixing” before the patient is positioned.
2. There is also a theoretical risk of the spinal anaesthetic obscuring paresthesia during the epidural catheter insertion.

3. It may be difficult to verify the position of the catheter because of difficulty identifying unintentional subarachnoid injections in the presence of existing spinal anaesthesia.1

These problems can be overcome if the double segment technique is used and the epidural space location and catheter threading is performed prior to subarachnoid puncture, by using Cook’s technique or by using the double lumen needles.

However the problems of prior placement of the epidural catheter has been enumerated by Rawal.1

1. Epidural test dose may make differentiation between spinal and epidural block difficult.

2. A portion of epidural test dose may appear in the hub of the spinal needle and cause confusion.

3. The final direction of epidural catheter is unpredictable. And may even tie itself in a knot.

4. Because, epidural catheter migration can occur over time, only a recent test dose holds significance.

5. The incidence of epidural catheter penetration through the dura has been reported to be more common with double segment technique than the single segment technique.

Tseng CH et al59 found that injection of 10 ml saline into the epidural space before catheter insertion could significantly diminish the incidence of epidural venous puncture by the catheter. Another method to ease the insertion of the catheter into the epidural space is by asking the patient to hold breath in deep inspiration so as to expand the epidural space cross-sectional area.60 Withdrawing the catheter 1-2 cm, rotating it along the long axis and re-advancing may also help in some cases of difficult catheterisation.57

Long term indwelling epidural catheters are best cleaned with pledgets impregnated with 10% povidone-iodine.61 The removal of catheter in the lateral position is reported to have a higher success rate than removing in the sitting position.62 Blackshear et al reported that catheters of high tensile strength should be used to minimize the chance of catheter tip breaking in the epidural space.63

Position

Yun et al64 found that hypotension was more severe and more difficult to treat when CSE for cesarean section was induced in the sitting versus the lateral position.

Test Dose

The location of the epidural catheter cannot be tested by injecting the usual volume of local anesthetic65, because of the risk of total spinal anesthesia if the catheter is placed spinaly. The conventional epidural catheter test dose consists of either 1 ml of hyperbaric lidocaine with adrenaline or 2 ml of 0.5% bupivacaine with adrenaline.66 With a correctly inserted epidural catheter, the block height will increase only approximately two segments. If the catheter has entered the spinal canal, the resulting block will not extend to a level causing diaphragmatic paralysis. Crawford in his review of 27,000 lumbar epidural blocks concluded that "the requirements for safety are that all top ups are given in divided dose, with an interval of approximately 5 minutes between two increments".67

When CSE is used in labour analgesia, a traditional epidural test dose causes unwanted loss of motor and proprioceptive functions, defeating the whole purpose of ambulatory analgesia or walking epidural in labour. In addition, traditional test doses frequently fail to detect subdural catheter placement.68 These concerns have urged some workers to advocate that when low-dose mixtures of opioid and local anesthetic are used, as in the CSE technique or for epidural analgesia alone for labour, epidural test doses are unnecessary.69

The debate on test dosing the epidural catheter with local anaesthetic may well be put to rest if the method described by Tsui BC et al70 and Ozawa T et al71 becomes simpler and more applicable. This method was to electrically stimulate the catheter tip and see the neuromuscular response and was reported to be more sensitive and specific than the standard test dose (3 ml lidocaine 1.5% with 1:200,000 epinephrine). The main drawbacks of this method being that the epidural catheter has already been placed and this method only verifies whether the catheter tip is in contact with a nerve or not. It cannot differentiate between an epidurally and a subdurally placed catheter.

Dosage in CSE

CSE often produces a more extensive block than expected. The following possible mechanisms have been postulated for the reduced epidural drug requirement in CSE:

1. Leakage of epidural local anaesthetic through the dural hole into the subarachnoid space.72

2. Continuing spread of initial subarachnoid block (unrelated to the epidural injection).1

3. Existence of “subclinical” analgesia at a higher level which is enhanced and becomes evident by perineural or transdural spread of epidural local anaesthetic.73
4. Change in epidural pressure. The pressure becomes atmospheric which may result in better spread of local anaesthetic because of an effect on volume and circulation of CSF.54

5. Epidural Volume Extension (EVE): Compression of subarachnoid space by the presence of epidural catheter and by the volume of local anaesthetic, resulting in a “squeezing” of CSF and more extensive spread of local anaesthetic.50,65,70,76,77,78

The necessary epidural dose for extension of a spinal block varies between 1.5 and 3 ml per added segment, less than needed for extending a conventional epidural anesthesia.30

Various aspects of the combined spinal epidural anesthesia, discussed above have been incorporated in many of the commercially available kits. Research is on and further improvements are expected in the near future.

References

CAUSES OF DIFFICULT INTUBATION
(PNEUMONICS/ACRONYMS FOR EASY REMEMBRANCE)

A – Ankylosis of TM joint, Acromegaly, Adentulous.
B – Bull neck, Beard individual, Big breasts, Burns contracture.
C – Collapsible pharynx, Cervical spine injuries, Cystic Hygroma, Cleft Lip, Cleft palate.
D – Down syndrome, Dentures.
E – Epiglotitis, Excessive pharyngeal tissue.
F – Fascio-maxillary injuries/abnormalities, F.B.
G – Goitre, Golden har’s Syndrome.
H – Hydrocephalus, High arched palate.
I - Inter Incisor Distance > 3.8 cm., Irradiation causing fixity of Larynx.
K – Kippel – Feil Syndrome.
L – Laryngeal oedema, Ludwigs Angina, Large Tonsils, Large tongue, Lock jaw, Large Incisors.
M – Micrognathia, Macroglossia, Mallampati score > 3.
N – Neck mobility, Neoplasms, No teeth.
O – Obesity, Odema in Ac. Burns, Over confidence of Anaesthesiologist.
P – Peritonsillar abscess, Pierre Robbinson Syndrome, Poor illumination of laryngoscope.
Q – Quinsy.
R – Retrognathia, Rheumatoid arthritis of TMJ/Cervical spine, Retropharyngeal abscess.
S – SAS, Short Neck, Snorer.
T – Tongue tie, Tracheal stenosis, Trismus, Treacher – collin syndrome.
U – Uvulitis/abcess.
V – Visualisation of only Epiglotis/only soft palate.
W – Wrong tube size, wrong laryngoscope blade, wrong assistant, wrong position and place, Webbed neck.
X – X-ray evidence of increased in mandibulo–hyoid distance. X – ray evidence of decreased space between C1 and occiput.
Y – Younger children – infants, new borns/Neonates.
Z – Zygomatic bone # and/dislocation.

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