Short-term changes of intraocular pressure after cervical interlaminar epidural injection: a pilot study

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Epidural steroid injections are one of the most commonly used methods for the treatment of herniated disc disease. Although epidural steroid injections are generally considered safe, a variety of complications have been reported. Several previous cases of transient blindness after lumbar epidural injection for back pain have been reported.1–5 The pathophysiology of this complication is unclear and it is suspected to be due to a rapid increase in cerebrospinal pressure or intracranial pressure (ICP) secondary to the injection, with a resulting increase in retinal venous pressure resulting in retinal haemorrhages.5 However, controversy remains regarding a correlation between ICP and intraocular pressure (IOP) in the literature.6–8

To the best of our knowledge, there were no existing literatures that examined changes in IOP after injection of drug into the epidural space. Our hypothesis was that cervical epidural injection (CEI) would possibly increase IOP due to a compressive effect on the subarachnoid space during the injection.

The aim of present study was to evaluate the short-term effects of CEI on non-invasive IOP measurements in subjects with normal eyes.

Methods

After gaining approval from the office of the Institutional Review Board of our hospital for human studies and obtaining patients' written informed consent, 15 volunteers were enrolled in the study. Inclusion criteria were a history of cervical disc herniation at the C5/6 level with a history of function-limiting neck and upper extremity pain; IOP measurement within reference range on both eyes (11–21 mm Hg) before CEI; age between 20 and 70 yr; and capacity to understand the study protocol and provide voluntary, written informed consent. Exclusion criteria were IOP measurements exceeding the reference range on both eyes before CEI; pre-existing...
eye disease or eye surgery (e.g. glaucoma, cataract, and retinal haemorrhage); history of spine surgery; pre-existing cranietomy or craniotomy; previous history of hypertension or diabetes mellitus; Cushing’s syndrome; and allergy to anaesthetics, steroids, or contrast agents.

All cervical interlaminar epidural injections were performed by a single physician from the pain clinic in an ambulatory surgery setting, in a sterile operating theatre, under fluoroscopy. For IOP measurements, a rebound tonometer (Icare-PRO, Icare Finland Oy, Helsinki, Finland) was used, and only one ophthalmologist was involved with the study. Our routine position for CEI is the prone position, but the study procedure was performed in the left lateral decubitus position to maintain the level of rebound tonometer horizontally during the IOP measurement of subjects. Baseline IOP values for the left and right eyes were measured 5 min after placement in the left lateral decubitus position (T0). After skin preparation and local infiltration, a 20 G 10 cm Tuohy needle was used. Access to the epidural space was obtained with the loss of resistance techniques under fluoroscopic visualization. The epidural space was entered between C5 and C6 with confirmation by injection of 4 ml non-ionic contrast. Once the needle tip was located in the epidural space, a mixture of 0.2% lidocaine 1 ml and normal saline 4 ml for irrigation and a mixture of normal saline 4.5 ml with non-particulate betamethasone 2 mg were injected. The injection speed was 1.0 ml s\(^{-1}\) and the total volume of injected materials was 14 ml. IOP was measured immediately after the end of CEI procedure (T1), 1 min after T1 (T2), and at 1 min intervals after each Ts (T3–T6).

As this was a pilot study, no formal sample size calculation was made. Instead, sample size was chosen as recommended for pilot studies within the range of 10–15.\(^6\) The differences of IOP values between time points were determined with the Kruskal–Wallis non-parametric analysis of variance with post-testing. Statistical significance was accepted at P-values below 0.05. Statistical analysis was performed using SPSS software package version 10 (SPSS, Chicago, IL, USA).

### Results

A total of 15 patients were enrolled in this study, and the patients’ characteristics are presented in Table 1. The values for left and right baseline IOP (T0) were 18.9 (2.0) and 15.6 (2.6) mm Hg at 5 min after left lateral decubitus position, respectively. IOP of left and right eyes at T1 [26.6 (4.2) and 21.2 (2.5) mm Hg, respectively] and T2 [26.2 (4.5) and 21.0 (2.8) mm Hg, respectively] were significantly higher compared with T0 (P<0.001) (Fig. 1). From T1 to T0, the mean differences in the left and right eyes were 7.68 and 5.63 mm Hg, respectively. These values immediately decreased at T3 and returned to baseline levels within 5 min after CEI. There was no CEI-related complication such as inadvertent dural puncture, haematoma, infection, or other neurological complications. There were also no eye-related complications such as changes in visual acuity or retinal haemorrhage.

### Discussion

The main finding in this study was that non-invasive IOP measurements increased immediately after CEI and that this effect was transient, being observed within 2 min after completion of CEI.

CEI has been reported to have good evidence of efficacy for radiculopathy secondary to a herniated disc, and fair evidence for spinal stenosis, discogenic pain, and failed neck surgery syndrome.\(^10\)\(^11\) Although CEI may be performed safely with caution, a variety of complications have been reported. These include inadvertent dural puncture, haematoma, infection, and other neurological complications. To date, 10 cases of transient blindness after lumbar epidural injection for back pain have been reported. Retinal haemorrhages were identified on ophthalmological examination in all cases. The suspected mechanism is due to a rapid increase in ICP secondary to the injection, with a resulting increase in retinal venous pressure resulting in retinal haemorrhages.\(^5\)

ICP is synonymous with cerebrospinal fluid (CSF) pressure and is defined as the pressure that must be exerted against a needle introduced into the CSF space to just prevent the escape of fluid. ICP depends on several parameters that are features common to any hydrodynamic system: the internal (intracranial) fluid volume, the elastance of the system, the contribution from the atmosphere, and the orientation of the craniospinal axis relative to the gravitational vector.\(^12\) Grocott and Mutch\(^13\) measured ICP after epidural anaesthesia in a porcine model. They demonstrated a correlation between epidural injection and ICP with a >90% reduction in cerebral

### Table 1

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Data Presented as Mean (sd) or Mean (range) for age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>51.3 (32–63)</td>
</tr>
<tr>
<td>Gender (F/M)</td>
<td>9/6</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>63.6 (9.5)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>163.5 (5.9)</td>
</tr>
</tbody>
</table>

### Fig 1

Changes in IOP during CEI. Measurements were recorded 5 min after left lateral decubitus position (T0, baseline), immediately after CEI (T1), 1 min after T1 (T2), and at 1 min intervals after each Ts (T3–T6). Bilateral IOP values at T1 and T2 were significantly higher compared with T0. *P<0.001 vs point T0.
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Blood flow (CBF) and spinal cord blood flow (SCBF). The prompt return of CBF and SCBF to baseline values by 100–160 s after epidural injection suggests preserved autoregulatory mechanisms. Usubiaga and colleagues demonstrated that an increase in epidural and CSF pressure is produced by injection of 20 ml of fluid into the lumbar epidural space in human subjects. A peak was reached immediately after the injection (epidural pressure as high as 65 cm H2O and CSF pressure as high as 85 cm H2O), and a return to the previous values was observed within 3–10 min. The magnitude of the pressure increase was found to be proportional to the speed and volume of injection.

Many previous studies have examined the relationship between ICP and IOP. However, the relationship between ICP and IOP has remained controversial. Sajjadi and colleagues examined ICP through lumbar puncture and IOP through the use of a Schiotz non-invasive tonometer, and suggested that IOP is correlated with ICP. Han and colleagues, however, rebutted the results of Sajjadi and colleagues. Their reasons included the fact that the Schiotz tonometer is an inaccurate instrument, and that the authors used the tonometer incorrectly. They suggested that no correlation is present between ICP and IOP through the use of a Goldmann non-invasive tonometer. Li and colleagues examined ICP and IOP using the same method as Sajjadi and colleagues with the only difference being in the type of tonometer; these authors used a Goldmann non-invasive tonometer. They also suggested that IOP is correlated with ICP. In the current study, we used a rebound tonometer, Icare-PRO. A previous study verified that the Icare-PRO shows an excellent agreement with the Goldmann tonometer. Furthermore, the Icare-PRO demonstrates significantly good correlation and agreement position independently.

The ultimate IOP is influenced by the production and outflow of aqueous humour but is balanced by the episcleral venous pressure (the Goldmann equation): [intraocular pressure (IOP) = secretion of aqueous (F)/facility of outflow (C) + episcleral venous pressure]. The episcleral venous pressure is influenced by the body position and venous drainage pressure in the superior/inferior ophthalmic veins, cavernous sinus, petrosal sinuses, and internal and external jugular veins. Thus, any abnormality leading to increased venous pressure in the venous drainage system downstream from the eye can lead to elevated IOP if the episcleral venous pressure is increased.

In our study, the baseline IOP of left eyes after 5 min after left lateral decubitus position was higher than that of right eyes [18.9 (2.0) vs 15.6 (2.6) mm Hg]. This reflects the gravitational or positional effect of IOP.

The suspected mechanism for the transient increase in IOP is compression of the dural sac after CEI. Because the cervical epidural space is smaller than that of the lumbar level, CEI is more likely than lumbar epidural injection to result in elevated ICP. The compressed dural sac causes a shift of CSF into the cranium that is followed by elevated ICP. However, this elevation in IOP does not continue for very long. Materials that are injected into the epidural space, such as normal saline and lidocaine, are absorbed into epidural adipose tissue or the systemic vasculature. This transient increase and prompt return of IOP to the baseline value after epidural injection was suggested by Grogg and Mutl, with preserved autoregulatory mechanisms in a porcine model. Giasi and colleagues reported that the venous plasma level of lidocaine after epidural injection was maximal at 15 min after administration and that the plasma level decreased after that. They suggested that the maximal epidural pressure does not pass 15 min, indirectly, the same as the ICP.

A limitation of this study is that concomitant measurement of epidural pressure or CSF pressure was not achieved. Therefore, we could not prove a direct relationship between IOP and epidural pressure. The speed and volume of the injection with regard to the magnitude of the pressure increase will require further study.

In conclusion, CEI resulted in an elevation of IOP of both eyes. However, the effects were transient, lasting only a few minutes.

**Authors’ contributions**

S.S.K.: study design, data collection, data analysis, and writing up the first draft of the paper; I.S.K.: data collection; J.H.P.: data analysis; S.J.H.: patient recruitment and data collection; H.K.S.: data collection; C.G.S.: study design and data analysis; Y.C.V.: study design and data collection; K.M.S.: patient recruitment and study design.

**Declaration of interest**

None declared.

**Funding**

This study was not supported by any institute.

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Handling editor: A. R. Absalom