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Spinal At T_{10} (10^{th} Thoracic)

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Abstract:
Background : *The historical evidence of the use of "general spinal anesthesia" introduced by Thomas Jonnesco in 1909 for the surgeries of the skull, head, neck and thorax puncturing the subarachnoid space (SAS) between 1^{st} and 2^{nd} thoracic vertebra producing perfect and deep analgesia for the above mentioned area influenced to puncture SAS at 10^{th} thoracic vertebra (T_{10}) in place of puncturing SAS between 12^{th} thoracic and 1^{st} lumbar vertebra proposed by Thomas Jonnesco for anesthesia of lower portion of the body including upper and lower abdomen.*
Method: *30 (thirty) patients of 59.23±7.219 years classified as ASA class 1 and 2 were selected for upper and lower abdominal surgeries by administration of lower thoracic spinal anesthesia at the level of T_{10} with 2.5 ml of 0.5% inj. bupivacaine at sitting position to each patient. Hypotensive episode was treated with increment doses of Mephentermine and anxiety of each patient was relieved with 2 mg of midazolam. Bradycardia was treated with inj. atropine. Supplemental oxygen was administered to each patient.*
Result: *Intrathecal procedure was operated successfully at the level of T_{10} without neural damage and intra-operative fall of blood pressure (98.00±6.034) mm of Hg and pulse rate (55.87±3.636) beats/minute was observed in each case from their base value (117.4±15.741) mm of Hg and heart rate (84.53±12.451) beats / minute respectively. No change of oxygen concentration (Spo_2) (98.77±0.817) % was observed in each case. Unchanged respiratory status maintained spo_2 in normal range.*
Conclusion: *With minimal hemodynamic instability and well controlled surgical stress response lower thoracic spinal anesthesia at the level of T10 is proposed to be good alternative technique to general anesthesia for open and laparoscopic surgeries in abdomen.*
Key words: *subarachnoid, lower thoracic, laparoscopic, intrathecal approach,*

I. Introduction

General anesthesia (GA) is the worldwide acceptable technique of anesthesia for abdominal surgeries particularly above umbilicus, but gradually it has been replaced by regional anesthetic (RA) techniques, such as lower thoracic epidural[1] and lumbar spinal[2]. Such replacement is not for avoidance of general anesthesia (G.A.), but for providing the benefits of regional anesthesia[3] to manage the patient with significant medical problems. Usually, classical intrathecal approach at lumbar region is not sufficient enough to satisfy the expectation of surgeon regarding muscular relaxation of anterior abdominal wall to achieve a relaxed and undisturbed surgical field and even at the time of laparoscopic procedure it is highly objectionable. To fulfill the above expectation regarding muscular relaxation, decision was taken to administer lower thoracic spinal anesthesia at level of 10^{th} thoracic vertebra (T_{10}) to achieve both sensory and motor block for lower 6 (six) thoracic intercostals nerves for evaluation of merits and demerits of this technique.

II. Methods

This protocol was approved by Medical Ethical Review Board of Howrah Orthopedic Hospital of Eastern Railways and written consent was received from the patients who participated in this study .It was multi centre study.

30(thirty) patients of both sex with mean age of 47.97±15.780 ranging from 20yrs to 70yrs and average body weight 59.23±7.219 kg classified as ASA class 1and 11 were selected for lower and upper abdominal surgeries for both open and laparoscopic hysterectomy, ovarian cystectomy, and cholecystectomy. This study was carried out within period of January, 2012 to June, 2013. After approval by the Institutional Ethical Committee and written informed consent, all patients were subjected to pre-anesthetic assessment. Patients with the history of Psychological disorders, coronary artery disease, uncontrolled hypertension, intracranial mass head injury, any abnormality of the spine, cutaneous infection, local cellulitis at the site, coagulation disorders, allergy to local anesthetic, history of opioid dependence, or neurological disorders were excluded from the study. The conditions that contraindicate the surgery or spinal anesthesia were considered at the time of preoperative visit. The patients were convinced and informed in details about the study.

In the operation theater, peripheral infusion was started with 5% glucose in normal saline[4] and patients were monitored continuously using standard monitoring techniques including electrocardiography, pulse oximetry and noninvasive blood pressure.

After this, in sitting position of patient, anatomical landmarks like inferior angle of scapula at the level of 7^{th} thoracic spinous process, scapular spine at the level of 3^{rd} thoracic spinous process and prominent 7^{th} cervical spinous process and 10th thoracic vertebral interspace were identified. (easily identified in thin persons but difficult in fatty persons.) The identified T_{10} was further confirmed by counting up from iliac crest. Nevertheless, exact vertebral interspace can be misplaced by one or two segments.[5]

After localization and identification of T_{10} vertebra, standard and usual aseptic preparation was done. The identified area was infiltrated with 4 ml of 1% inj. xylocaine. Lateral approach technique for spinal anesthesia was adopted here. The spinal needle (romsons^{r} 26 ga o.46 x 90 mm) was inserted at a point of one finger breadth lateral to midline and then advanced forward almost at an angle of 45 degrees cephalad and 45 degrees to midline to enter the ligamentum flavum. The free flow of CSF through the spinal needle confirmed its placement in subarachnoid space. The local anesthetic solution like 3 ml of 0.5% inj. bupivacaine was administered intrathecally to each patient through the spinal needle.

Heart rate, blood pressure, respiration, and oxygen concentration were recorded every three minutes for first 10 minutes after which taken at every ten minutes interval. Upper level of sensory block was assessed by pinprick and motor block by modified Bromage scale. The onset time of sensory blockade was defined as an interval between intrathecal injection and bilateral loss of sensation along the midclavicular line. Duration of sensory block was defined as time interval between injection and complete recovery of sensation.[6] Complete motor block of lower extremities was defined as inability to move feet or knees. Supplemental oxygen at the rate of 3 L/min was administered via a Hudson face mask during the surgery. Hypotension was defined as a fall in systolic blood pressure (SBP) of >20% of baseline value or <100 mm Hg and was treated with increment doses of Mephentermine 6 mg .

Once the block was satisfactory, surgery was allowed and patient was frequently enquired for discomforts, pain, and wish for conversion. Inj. midazolam 2 mg was administered for anxiety. Hypotension was treated with inj. Mephentermine. No conversion to general anesthesia was requested both by patient and surgeon. Visceral manipulation did not cause any kind of discomfort to patient. Onset time of sensory blockade, onset time of complete motor blockade, duration of sensory block, duration of surgery, blood pressure, pulse rate and SPO_2 were recorded. Enquiry for post-dural puncture headache (PDPH), backache and epidural hematoma were done.

Good muscular relaxation of anterior abdominal wall was experienced by surgeons. Intestinal movement was absent. Visceral manipulation during surgeries did not cause disturbance to patients and surgeons.

III. Results

This study has evaluated the clinical applicability and its efficacy of lower thoracic spinal anasthesia administered at the level of T10. 30 consented patients, scheduled for elective surgeries on upper and lower abdomen. The demographic profile of 30 elderly patients of mean age of 47.97 ±15.780 years with mean weight of 59.23±7.219 kg was male predominant. No protocol deviation either in preoperative or intraoperative period was done.

The hemodynamic characteristics of the baseline preoperative heart rate and systolic blood pressure (SBP) along with intraoperative variation of heart rate and SBP are shown in Table no 2. The mean values of heart rate (55.87±3.636) beats/ minute and systolic blood pressure (98.00±6.034) mm of Hg showed significant decline from the base value like heart rate (84.53±12.451) beats / minute and systolic blood pressure (117.4±15.741) mm of Hg. Hypotension and bradycardia were noted. Smooth respiration without change of rate was noted maintaining spo_2 in normal range.

The sensory and motor block characteristics are shown in [Table 3].The mean±SD of onset time of motor block (12.00±4.842) minutes was greater than that of sensory block (8.93±1.258) minutes at level of T_4. The duration of sensory block (188±8.054) minutes was prolonged than that of motor block (154.67±6.814) minutes.

IV. Discussion

Since the introduction of spinal anesthesia in 1898 by Bier, it is traditional, in most cases, to puncture subarachnoid space (SAS) at well behind the termination of spinal cord but above the end of dural sac to avoid the neural damage. But in 1909, Thomas Jonnesco[7] proposed the use of general spinal block for the surgeries of the head, neck and thorax puncturing SAS between 1^{st} and 2^{nd} thoracic vertebra and succeeded to produce profound analgesia for the area of head, neck and upper limbs. He also punctured SAS between 7^{th} and 8^{th} thoracic vertebra for mid thoracic surgeries and for the rest of the body, he punctured SAS between 12^{th} thoracic and 1^{st} lumbar vertebra. Over and all, above activities of Thomas Jonnesco exposed the possibilities of safe puncture SAS above the termination of spinal cord i.e. in presence of spinal cord. In 1954, Frumin et al proposed the use of segmental spinal block by introducing radio opaque catheter in SAS at the level of T_{12} vertebra through lumbar puncture with 5% procaine[8].

In 2006, the new era of studies on segmental spinal anesthesia puncturing SAS at T_{10} for laparoscopic cholecystectomy started to anesthetize a patient with severe obstructive lung disease[9]. In the following year, lower thoracic spinal anesthesia at T_{10} in lateral position of patient was introduced successfully to achieve the segmental spinal anesthesia for laparoscopic cholecystectomy[10].

Lower thoracic spinal anesthesia, being an access to SAS at the level of T_{10} and also in presence of spinal cord and its associated nerve roots is against our traditional belief regarding administration of spinal anesthesia. In this study, the 10th thoracic inter-space is selected to puncture the subarachnoid space assuming it as centre of dermatomal innervations of the surgical field (abdominal wall), although it is not fixed one. It may be altered depending on need and easiness of entry.

The magnetic resonance imaging studies demonstrated the existence of space between meninges and spinal cord[11] and it is found to be greatest at the level of 5th thoracic vertebra measuring 7.75 mm. The space is also found to be 5.19 mm at the level of T_2 and 5.88 mm at the level of T_{10}. These measured spaces between dura mater and spinal cord help to avoid spinal cord injury and neural damage. This distance is also elongated by the angulation of entry of needle to avoid the chance of neural damage and spinal cord injury. MR imaging confirms that the cord and the cauda equina are touching the dura mater posteriorly in the lumbar region and anteriorly in the thoracic region (the spinal cord). This position increases the distance to a point that permits the advancement of a needle without touching the cord. This anatomical distribution of the space between dura mater and spinal cord in the thoracic region is an explanation for the low incidence of neurological complications that are absent in this study.

Subarachnoid myelography, done by puncturing the thoracic and cervical[12] arachnoid space was common and advocated to use it as alternative to lumbar puncture.[13]This procedure is safe but occasionally "electrical feeling" caused by penetration of spinal needle into spinal cord was noticed, but without complications[14].

Spinal anesthesia, administered by lateral approach in sitting position of patient at the level of T10 is always associated with possibilities of potential dangers of neural damage. Careful attention to identify the loss of resistance at the time of puncturing dural sac by the spinal needle may be marked as essential and important step of successful subarachnoid block with avoidance of neural damage. Formation of some degree of dural tenting before puncturing the dural sac is the usual occurrence of this procedure. The sensation like paraesthesiae carries some significant indication of neural contact by spinal needle although failed to identify whether it is caused by spinal cord or nerve root. For above reasons it is recommended to keep it reserved for experienced and expert clinicians and not advocated for routine use.

In this procedure, paralysis of primary expiratory muscles in the anterior abdominal wall is liable to produce another potential danger. Its consequence may be reflected to respiratory status of the patients. So it may be expected that patients without respiratory disease are liable to show its little consequence, but, there is always possibility of inadequate ventilation due to extensive thoracic nerve block, although the main respiratory muscle, diaphragm, remains unaffected as it is innervated from cervical region. Expiration is a passive phenomenon and normally it is not effected, but forceful expiration and coughing will be effected because they are generated by abdominal muscles of anterior wall innervated by thoracic nerves.[15,16] Clinically no patient is experienced with dyspnoea, fall of oxygen concentration (Spo2) and increase or decrease of respiratory rate. Cardiovascular changes were minimal, even though local spread of anesthetics, as judged by sensory block, spread to affect most of the spinal cord segments responsible for sympathetic outflow.

Chance of neural damage at the time of intrathecal procedure by spinal needle insertion above the termination of spinal cord is potentially dangerous and needs more perfect anatomical conception in relation to spinal cord and spinal canal for avoidance of the neural damage[17]. The thoracic segment of spinal cord lies anteriorly in relation to supine and extended position of body. Recent MRI report suggests a little change of conus medullaries in flexed lateral position of body.[18] Damage to conus medullaries was observed following spinal anesthesia.[19] Another review suggests that at the time of cervical myelography, the complication like neural damage with intrathecal insertion of spinal needle is more common in extended position of neck than flexed one.[20]

The caudal spread of hyperbaric local anesthetic after administration of the same during lower thoracic spinal anesthesia at the level of T_{10} in sitting position of patient is usually natural phenomenon with involvement of the lumbo-sacral plexus resulting the complete motor block of lower limbs and rare occurrence of only segmental block of abdominal innervations extending T_7-T_{12} inter-costal nerves. This sitting position of patient at the time of intrathecal procedure helps to limit the cephalad spread of local anesthetic.

The low incidence of side-effects of lower thoracic spinal anesthesia made it suitable to use, of course, they were infrequent and easily manageable. Avoidance of extreme degrees of head down tilt helped to have less amount of blood and other irritant fluid on the under surface of diaphragm to cause shoulder tip pain.[21] Most probably, this happened so due to the sensory block of diaphragmatic innervations by lower 6(six) intercostals nerves at its periphery to make it unresponsive to irritant fluid and surgical manipulation of abdominal organs by the surgeons at the time of surgical procedure.

The importance of high quality analgesia in early post-operative period has been discussed by Mcleod and colleagues[22]. The adequate, effective, analgesic benefit from regional anesthesia is enough sufficient to fulfill above purpose. The provision of well controlled surgical stress response, minimal physiological disturbance with good adequate muscular relaxation of anterior abdominal wall and profound postoperative analgesia are sufficient to replace GA for upper and lower abdominal surgery.

A successful feasibility study for laparoscopic cholecystectomy under segmental thoracic spinal anesthesia was performed without any neural damage and adverse cardio-respiratory effect[9,10] evaluating its efficiency as safe and well accepted procedure with advantages of regional nerve block.

Adverse effects related to medications used in extradural and subdural procedures include nausea, vomiting, pruritus, hypotension, urinary retention, sedation, and respiratory depression. Reports of dysesthesia, paresthesias, weakness, and local anesthetic toxicity are rare. Rare but devastating complications of epidural analgesia include neurologic injury from hemorrhagic and infectious etiologies. The incidence of epidural abscesses appears to be low.

The chances of neural damage related to techniques at the time of either epidural or intrathecal procedures in the thoracic level are usually same, of course, they occur less frequently and also not in severe form. Unintentional dural perforation was observed more often during lower thoracic epidural procedure, but no epidural hematomas or abscesses were identified.[23, 24,25] The absence of neurological sequelae caused by thoracic epidural procedure is supported by other studies.[13,14]

V. Conclusion

With minimal hemodynamic disturbance, well controlled surgical stress response and maximal physiological stability lower thoracic spinal anesthesia is proposed to be an alternative technique of general anesthesia for open and laparoscopic procedure of abdominal surgeries.

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Table1.
Demographic profile of the patients

Age	47.97±15.780
Height	160.10±7.862
Weight	59.23±7.219
Sex	M:F::14:16

Table 2
Hemodynamic parameter systolic blood pressure, heart rate and oxygen saturation

Systolic blood pressure(mm of Hg)	98.00±6.034
Heart rate (beats/min)	55.87±3.636
Oxygen saturation (SPo_2 %)	98.77±0.817

Table 3
Sensory and Motor block profile of anesthesia.

On set time of sensory block at T_4(min)	8.93±1.258
Maximum height of sensory block (vertebral level)	T_4
Duration of sensory block (min)	188±8.052
On set of Complete motor block (min)	12.00±4.842
Duration of motor block (min)	154.67±6.814

Table 4
Operative Details

Duration of surgery (min)	73.30±10.059
Post- operative analgesia (min)	379.69±22.512