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RESEARCH ARTICLE

COMPARISION OF DEXAMETHASONE AND MAGNESIUM SULPHATE AS ADJUVANTS TO BUPIVACAINE FOR POSTOPERATIVE ANALGESIA IN LOWER ABDOMINAL SURGERIES USING TRANSVERSUS ABDOMINIS PLANE BLOCK

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Abstract

Background:Transversus abdominis plane block is regional anaesthesia technique that provides analgesia to the parietal peritoneum as well as skin and muscles of the anterior abdominal wall.Magnesium is N-methyl D-aspartate receptor and physiological calcium antagonist.Dexamethasone is a potent glucocorticoid,has anti-inflammatory as well as analgesic properties.

Objectives: To compare the duration of postoperative analgesia,time of administration of first rescue analgesia,systemic side effects of Bupivacaine with Magnesium sulphate and Dexamethasone using Transversus abdominis plane block.

Methods: After approval of ethical committee and informed written consent A total of Sixty ASA grade I and II patients aged between 18-60 years undergoing lower abdominal surgeries were randomnly allocated to receive TAP block and divided into two groups of 30 each . Group BD received 20ml of 0.25% Bupivacaine +2ml(8mg) Dexamethasone , Group BM received 20ml 0f 0.25% Bupivacaine+1ml of 25% Magnesium sulphate(250mg)+1ml of normal saline respectively.Heart rate,mean arterial pressure,VAS score,time for first rescue analgesia and side effects were recorded postoperatively. Analgesia was given when VAS score was more than 4.

Results: The postoperative visual analogue scale scores was significantly less in group BM.Time for first rescue analgesia was more in group BM compared to group BD without any systemic side effects .

Conclusion:Administration of Magnesium sulphate with Bupivacaine reduces postoperative pain scores, prolongs the postoperative analgesia compared with Dexamethasone without any systemic side effects

Introduction:-

Postoperative pain is often treated with systemic or neuraxial opioids. Although single-shot neuraxial analgesic technique using long-acting opioids, or patient-controlled epidural opioid administration, produce effective

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analgesia, they are associated with side effects, like nausea, vomiting, and pruritus, which reduces overall patient satisfaction.[1,2] Use of opioids and their subsequent side effects can be reduced or eliminated by regional anaesthesia with local anaesthetics. Direct blockade of the neural afferent supply of the abdominal wall, such as abdominal field blocks, ilioinguinal, and hypogastric nerve blocks provide significant postoperative analgesia in patients undergoing lower abdominal surgeries.[3] However, the lack of clearly defined anatomical landmarks make the abdominal wall blockade difficult in patients undergoing lower abdominal surgeries . All these lead to the development in new post operative pain relief methods. An alternative, simple, reliable and effective regional analgesic technique is required.

An important component of pain experienced by patients after abdominal surgery is from the abdominal wall incision. The nerves that supply the anterior abdominal wall course through the neurofascial plane between internal oblique and transversus abdominis muscles.[4,5] By injecting local anaesthesia into the transversus abdominis plane via petit triangle, it is possible to block the sensory nerves of the anterior abdominal wall, before they leave this plane and pierce the musculature to innervate the entire anterior abdominal wall on that side.[6,7] TAP Block as a part of multimodal analgesic regimen would result in decreased opioid consumption and improved analgesia.[8-11]Thus the efficacy of Transversus abdominis plane (TAP) block in providing postoperative analgesia in lower abdominal surgery is evaluated in this study.

Bupivacaine is the indicated local anaesthetic in caudal, epidural, spinal and regional anaesthesia and also provides post-operative analgesia ,hence is widely used clinically to manage acute and chronic pain with long duration of action of 180-300 minutes. In addition to blocking Na channels, bupivacaine affects the activity of many other channels, including NMDA receptors. Importantly, bupivacaine inhibits NMDA receptor-mediated synaptic transmission in the dorsal horn of the spinal cord, an area critically involved in central sensitization of bupivacaine would decrease the peak and accelerate the decay of synaptic NMDA receptor currents during normal synaptic transmission. These quantitative predictions inform possible applications of bupivacaine as preventative and therapeutic approaches in chronic pain[12] It has also less incidence of nausea, vomiting and pruritis when compared with opioids. However it can cause some amount of motor blockade and hypotension.

Magnesium is the fourth most plentiful cation in the body and the second most plentiful intracellular cation after potassium. Magnesium is necessary for the presynaptic release of acetylcholine from nerve endings and may produce effects similar to calcium-entry-blocking drugs.[13]Anti-nociceptive effects of magnesium are due to regulation of calcium influx into the cell and antagonism of the N-methyl D-aspartate (NMDA) receptors.[14] Many clinical investigations have demonstrated that Mg administration during general anesthesia has reduced anesthetic requirement and postoperative analgesic consumption. [15,16] Magnesium has popularly been used as antihypertensive agent. [17]Thus, magnesium has been used for its analgesic, antihypertensive, and anesthetic sparing effects.[18] Magnesium, after administration through epidural route, decreased postoperative opioid consumption.[15] Though magnesium has an analgesic property, it has not been studied well as an adjuvant to the local anesthetic agents during transversus abdominis plane block.

Dexamethasone is a systemic glucocorticoid commonly used to reduce postoperative pain,nausea,vomiting and to improve quality of recovery after surgery.[19-21]Recently, several studies have examined the use of perineural dexamethasone in order to prolong analgesic duration of peripheral nerve blocks with variable results.However, the aggregated effect of perineural dexamethasone an analgesia outcomes has yet to be quantified. In addition, the safety of perineural dexamethasone also needs to be further examined.[22]

Hence this clinical study is undertaken to compare the duration for post-operative analgesia ,time for first rescue analgesia and systemic side effects of Bupivacaine with Magnesium sulphate and Dexamethasone as adjuvants in Transversus abdomins plane block.

Materials And Methods:-

After obtaining approval from the institutional ethical committee and after obtaining written informed consent from each patient ,this prospective randomised controlled study was carried out in 60 ASA I & ASA II patients of both sexes aged between 18 years to 60 years undergoing elective lower abdominal surgeries .Patients refusal of block,local infection at the site of needle insertion for block, renal,hepatic impairment,cardiac disease,coagulopathy or receiving anticoagulants or opioids,patients on calcium channel blockers, or allergy to the drug were excluded from the study.

During preanaesthetic visit,the patients were explained about the TAP block,advantages and risk of procedure and were instructed to demand analgesia as per requirement. Patients were educated about visual analogue scale(VAS:0-no pain,10-worst pain).All patients were assessed with regards to haemodynamics including heart rate(HR),mean arterial pressure(MAP) and oxygen saturation(SPO2) .Patients were kept nil per oral for 8 hours before surgery. In operation theatre,an Intravenous access had been established and an infusion of crystalloid commenced.Standard monitors were attached and Heart rate, Blood pressure and oxygen saturation were monitored.Patient underwent lower abdominal surgery.Ultrasound guided Transversus abdominis plane block was given to the patient after completion of surgery in General anaesthesia and after one and half hour in Regional anaesthesia.No adjuvant was added for Regional anaesthesia.

Under all aseptic precautions, the ultrasound probe was placed midway between the costal margin and the iliac crest in the mid-axillary line. The muscle layers were identified. The needle was gradually passed through the skin, subcutaneous tissue, external oblique and internal oblique until it lies between internal oblique and transversus abdominis.Study drug was slowly injected .If the needle was correctly positioned, the fascial plane was seen to separate and form a well-defined, hypoechoic, elliptical shape between the internal oblique and transversus abdominis muscles. It is essential to watch for spread of the drug.The quality and duration of analgesia was assessed in both groups and comparision was done

Patients were randomized, by a sealed envelope technique, into one of the two groups.
Group BD received 20ml of 0.25% Bupivacaine plus 2ml(8mg) Dexamethasone .
Group BM received 20ml of 0.25% Bupivacaine plus 1ml of 25% Magnesium sulphate(250mg) plus 1ml of normal saline .

Postoperatively heart rate,mean arterial pressure were recorded every 2 hourly at 0,2,4,6,8,10,12 hours.The duration of analgesia,time for first recue analgesia was assessed in both groups and comparision was done.

Duration of analgesia was taken from the time of administration of drug to the time of giving first rescue analgesia.The patients were taught to assess the intensity of pain using visual analog scale(VAS) for post operative pain assesement and systemic side effects related to the drugs and TAP Block were recorded.VAS was monitored every 2nd hourly in the post operative period. Post operative analgesia was given when the patient complaints of moderate pain (VAS>4)

Statistical Analysis
Statistical data was analyzed by IBM SPSS 25.0 version software. Collected data were spread on excel sheet and master chart was prepared. Through the master chart tables and graphs were constructed.

For quantitative data analysis,descriptive statistics were done like mean, standard deviation . Independent samples “t ” test was used to compare the mean values between two variables for statistical significance.

For qualitative data analysis chi-square test and Fisher exact probability tests were applied for statistically significant data. $P \leq 0.05$ was considered statistically significant for all comparisons.

Results:-

The study groups did not show any statistical difference as regards to demographic data,postoperative haemodynamics such as Mean Heart rate[Figure1],mean arterial pressure(MAP)[Figure 2],ASA grade [Table :1] P>0.05.

There was no statistically significant data with regards to surgical procedure [Table:2] P>0.05.

The time for first rescue analgesia was 5.76 ±0.62 hours in group BD and 10.93 ± 1.02hours in group BM which was statistically highly significant (P<0.001)Figure 5,Table :4

Pain intensity was assessed using the visual analogue scale (VAS) post-operatively at 0,2,4,6,8,10 and 12 hours.The mean VAS pain score was significantly higher in group BD as compared to Group BM at 2 and 4 hours.Thereafter first rescue analgesia was given to group BD at 4th and 6th hour and Group BM at 10th and 12th hour.There was no

statistical significant difference of mean VAS pain score between group A and Group B at 0 and 12th hour post operatively.[Table:3]

There was statistically highly significant difference of mean VAS score between Group BM and Group BD at 2,4,6,8and 10 hours of postoperative period (P<0.001).Figure 4

No significant differences were recorded regarding incidence of any side effects such as nausea,vomiting between two groups .[Table :1]

Table 1:- Demographic Data.

	GROUP BD		GROUP BM		P VALUE
Gender	No	%	No	%	
Male	16	53.3	20	66.7	0.821
Female	14	46.7	10	33.3	
Age	33.83 ± 11.27		33.95±11.87		P = 0.991
Weight	58.46±6.91		60.47±5.46		P= 0.219
Height	159.33±6.60		161.20±6.60		P= 0.163
ASA grade					
I	26	86.7	25	83.3	P= 0.923
II	04	13.3	05	16.7	
Side effects					
Nausea and vomiting	4	13.3	2	6.7	P= 0.478

Surgical procedure	**Group BD**		**Group BM**		**Total**	
	No.	**%**	**No.**	**%**	**No.**	**%**
APPENDICECTOMY	17	56.8	16	53.4	33	55.0
HERNIOPLASTY	9	30.0	10	33.3	19	31.7
TAH	2	6.7	3	10.0	5	8.3
CYSTECTOMY	1	3.3	1	3.3	2	3.3
LAPAROTOMY	1	3.3	0	0.0	1	1.7
Total	30	100.0	30	100.0	60	100.0
X^2 -test value, P-value	**X^2 = 0.069**	**P = 0.984**	**NS(Nothing significant)**			

Table 2:- Surgical procedure wise distribution of cases among Group BM and Group BD.

Fig 1:- Line diagram representing mean heart rate of the cases.

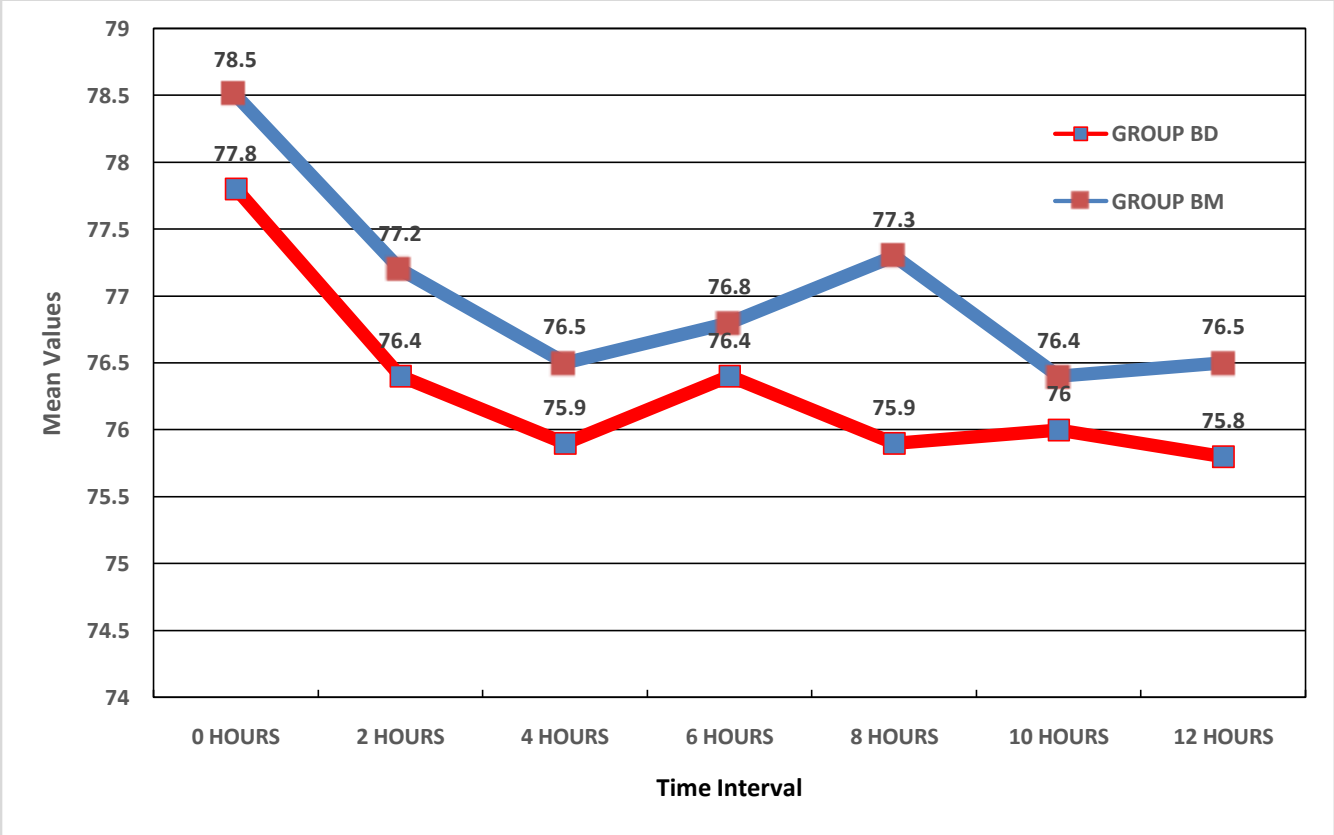

Fig 2:- Line diagram represents mean arterial pressure of two groups.

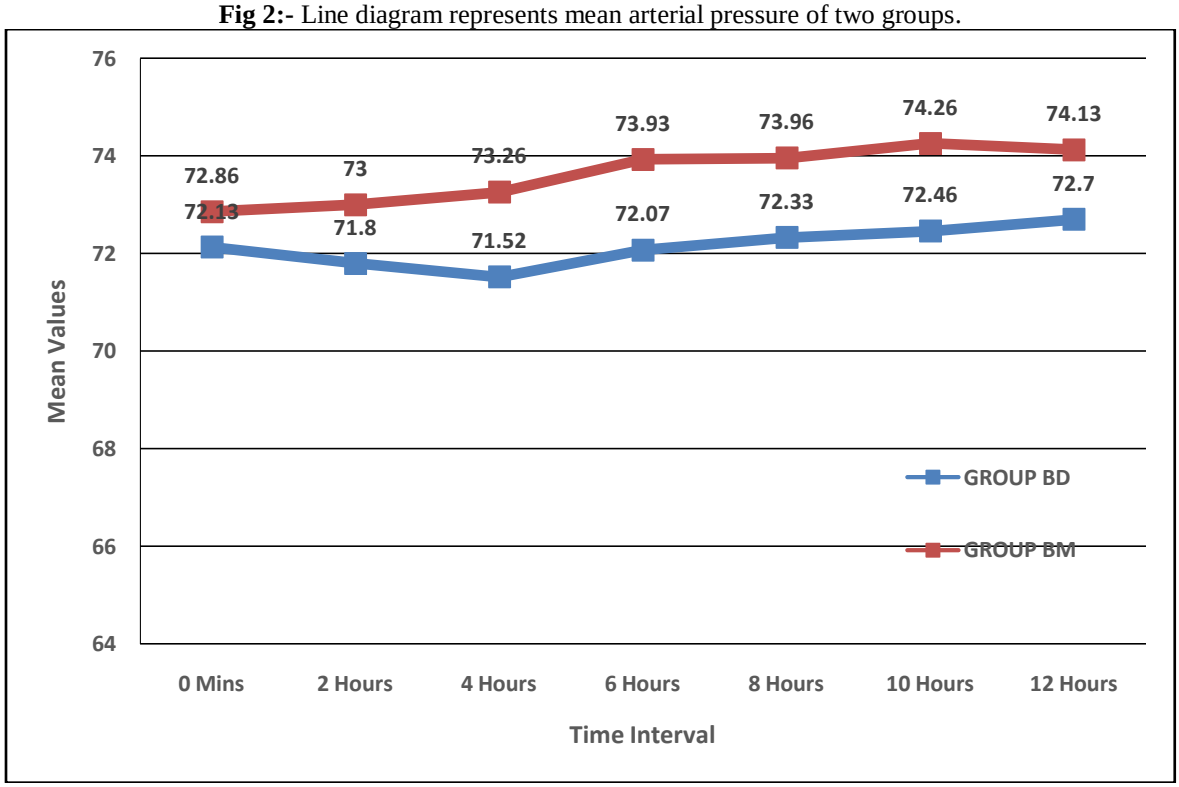

Table 3:- Comparison of Mean VAS score of pain of cases between Group BD and Group BM.

Time Period	VAS score				
	Group BD	Group BM	Std. Error	t –test value	P- value & Significance
	Mean ± SD	Mean ± SD			
0 hours	0.57 ± 067	0.2 ± 0.40	0.123	t = 2.137	P = 0.091, NS
2 hours	1.86 ± 0.63	1.16 ± 0.37	0.114	t = 5.222	P = 0.002, HS
4 hours	3.00 ± 0.78	1.50 ± 0.57	0.143	t = 8.437	P = 0.000, HS
6 hours	4.26 ± 1.11	2.03 ± 0.49	0.203	t = 10.065	P = 0.000, HS
8 hours	1.70 ± 0.46	2.67 ± 0.47	0.085	t = -7.918	P = 0.000, HS
10 hours	1.96 ± 0.18	3.76 ± 0.81	0.274	t = -11.774	P = 0.000, HS
12 hours	2.96 ± 0.18	2.16 ± 2.37	0.434	t = 1.786	P = 0.089, NS

Figure 4:- Line diagram represents mean VAS pain score of the cases.

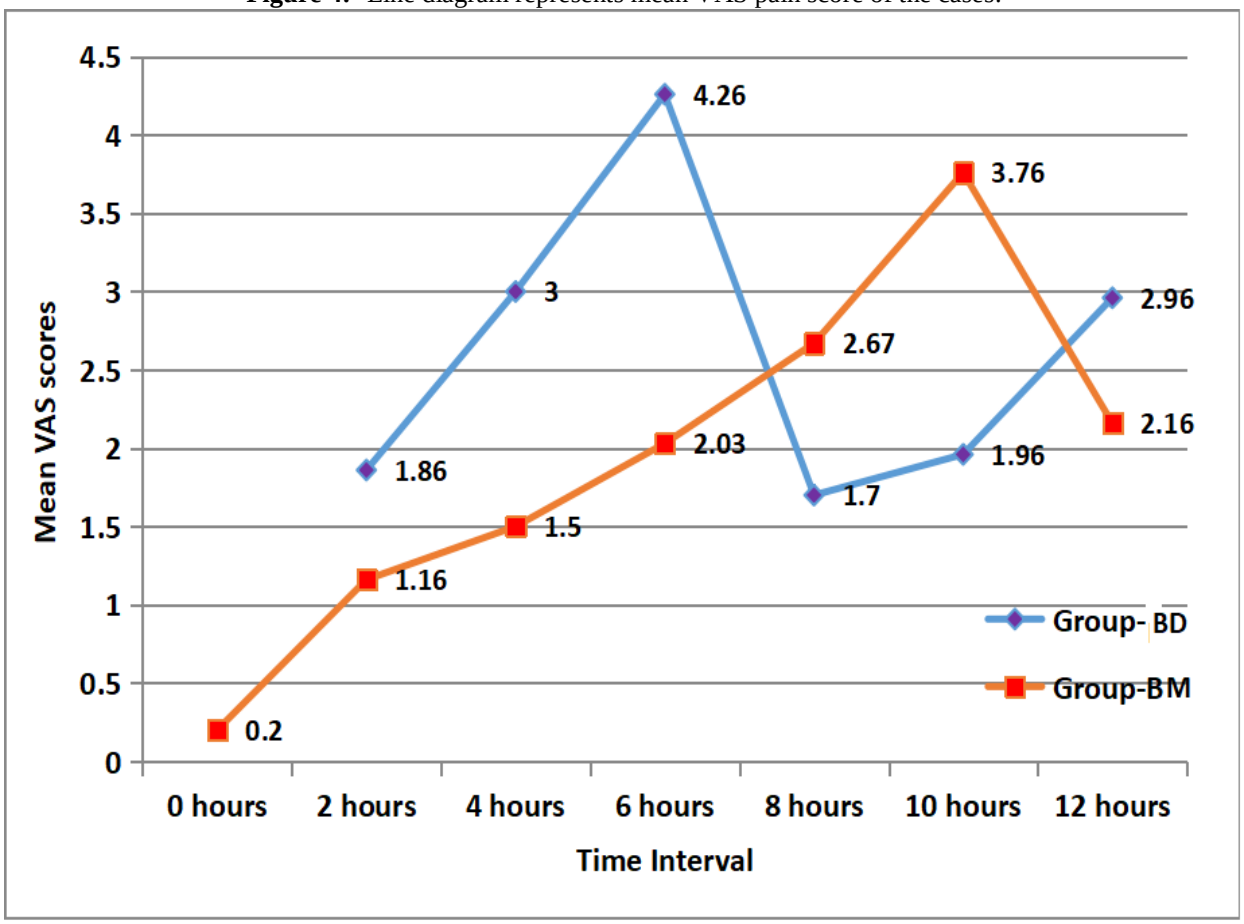

Figure 5:- Simple bar diagram representing the comparison of duration of time for first rescue analgesia between the two groups.

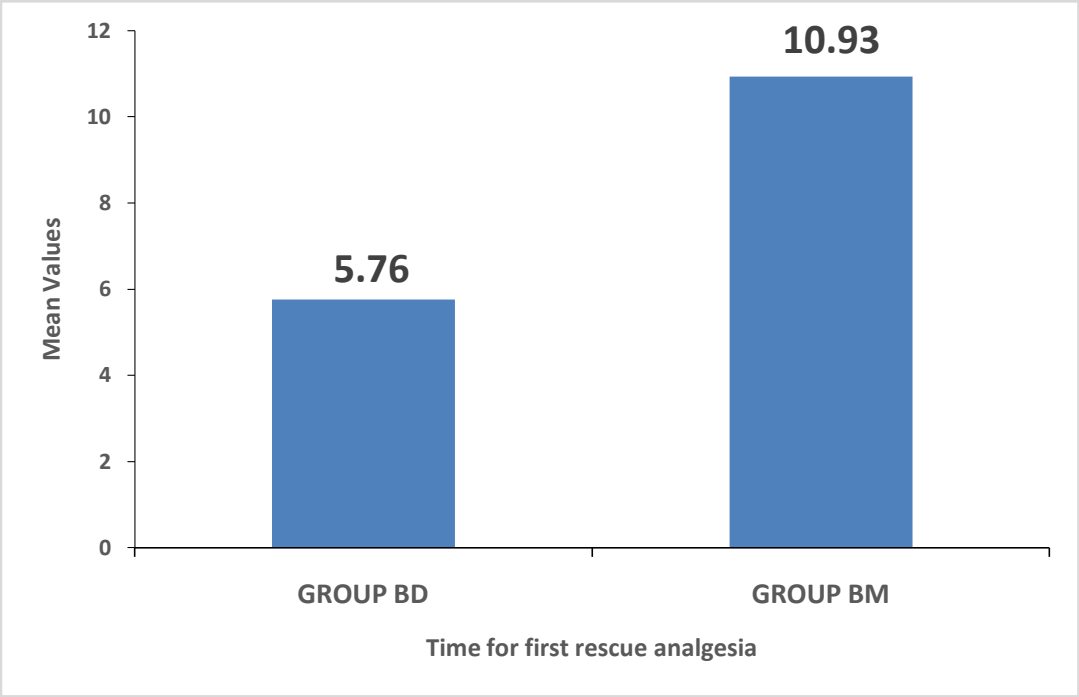

Table 4:- Comparison of Time of rescue analgesia in hours between the groups.

Groups	Time of rescue analgesia Mean ± SD	t –test value	P- value & Significance
Group-BD	5.76 ±0.62	t = 23.733	P = 0.000, HS (highly significant)
Group-BM	10.93 ± 1.02		

Discussion:-

The benefits of adequate post-operative analgesia are clear and include a reduction in the post-operative stress response,reduction in post-operative morbidity and in certain types of surgery improve surgical outcome.Effective in controlling pain also facilitate rehabilitation and accelerates recovery from surgery.Other benefits of effective regional analgesic technique include reduced pain intensity, decreased incidence of side effects from analgesic and improved patient comfort.

Adding MgSo4 as an adjuvant to local anesthetics in regional procedures has proofed its efficacy in many clinical trials.[23-26]The mechanism of action by which TAP MgSo4 potentiates the analgesic effect of local anesthetics still is not clear and may be related to systemic and or local actions. The analgesic effects of Magnesium are primarily based on antagonism of calcium influx into nerve fiber, and NMDA receptor blocking activity[27-32]thus interfering with the release of neurotransmitter substances at synaptic junctions or may potentiate the action of localanesthetics.[33]

Dexamethasone relieves pain as it reduces inflammation, blocks the transmission of nociceptive C-fibers in addition to suppresses ectopic neural discharge. The duration of postoperative analgesia is prolonged when dexamethasone is used as an adjunct for peripheral nerve blocks[34]

In this prospective interventional randomised study,the analgesic efficacy of bupivacaine with magnesium sulphate and Dexamethasone given through TAP block in patient undergoing elective lower abdominal surgeries was evaluated.In the present study,there were no significant haemodynamic changes and side effects were seen between groups

K Al-Refaey evaluated that administration of magnesium as adjuvant to bupivacaine in TAP Block improves post-operative analgesia in the form of increased duration,decreased analgesic requirements and PONV without any significant haemodynamic changes.[35]

The mean VAS pain score was significantly higher in group BD as compared to Group BM at 2 and 4 hours.Thereafter first rescue analgesia was given to group BD at 4th and 6th hour and Group BM at 10th and 12th hour.There was no statistical significant difference of mean VAS pain score between group BD and Group BM at 0 and 12th hour post operatively.

There was statistically highly significant difference of mean VAS score between Group BD and Group BM at 2,4,6,8and 10 hours of postoperative period ($P<0.001$)

Similarly study done by K Al-Refaey et al showed reduced postoperative visual analogue score and prolonged duration of analgesia with bupivacaine and magnesium sulphate group than bupivacaine group in patients undergoing laparoscopic cholecystectomy.

Castillo et al. stated that addition of dexamethasone microspheres to bupivacaine resulted in prolongation of sciatic nerve blockade in rats.[36] Droger et al.have shown that dexamethasone incorporation into bupivacaine microspheres caused prolongation of the intercostal nerve blockade in sheep. These studies have attributed the prolongation of the block duration to the anti-inflammatory effect of steroids.Therefore, this study intended to compare MgSO4 and Dexamethasone in USG-guided TAP block as adjuvants to bupivacaine in patients scheduled for lower abdominal surgery.[37]

In our study, time for first rescue analgesia (TFA) in (magnesium group) Group BM is 10.93±1.02 hours and Group BD is 5.76±0.62 hours .

This study reveals that there was statistically highly significant difference of mean time of rescue analgesia in hours between Group BD and Group BM($P<0.001$) and prolongs the duration of analgesia without any significant side effects such as nausea and vomitting .

Kerdawy et al [38] defined time for first rescue analgesia as the time from the completion of surgery till the time of first use of rescue medication by PCEA. Since each surgery may have different durations, in our study, we defined time for first rescue analgesia as the time from the injection of the study drug through TAP block to the time when visual analogue score reaches 4 in the postoperative period

Shelly Rana et al,found that magnesium sulphate as an adjuvant to bupivacaine in USG-guided TAP block reduces post-operative pain scores,prolongs the duration of analgesia and decreases demands of rescue analgesics.[39]

Bondok and Abd El-Hady also found significant reductions in postoperative VAS scores during the use of MgSO4 in femoral nerve blocks and intra-articular blocks.Regarding nausea and vomiting, there was no significant difference in nausea-vomiting in both the group, which may be attributed to lower opioid consumption in the magnesium group and also to the antiemetic properties of dexamethasone. [40]

Our study has a limitation.We did not measure the serum Magnesium level.

Conclusion:-

This study showed that addition of MgSO4 to Bupivacaine in an ultrasound guided TAP block significantly reduced postoperative analgesia,prolonged the duration of analgesia and reduced VAS scores campared to addition of dexamethasone to bupivacaine in patients who underwent lower abdominal surgery without any significant side effects

References:-

1. Farragher RA, Laffey JG. Postoperative pain management following cesarean section. In: Shorten G, Carr D, Harmon D, et al., eds. Postoperative pain management: an evidence-based guide to practice. 1st ed. Philadelphia, PA: Saunders Elsevier, 2006:225–38.

2. Overdyk FJ, Carter R, Maddox RR, Calura J, Herrin AE, Henriquez C. Continuous Oximetry/Capnometry monitoring reveals frequent desaturation and bradypnoea during patient controlled analgesia. Anesth Analg 2007; 105(2):412-418.
3. White PF. The role of non-opioid analgesic techniques in the management of postoperative pain. In: Hadzic A. Textbook of Regional Anaesthesia and Acute Pain Management New York, NY: McGraw-Hill; 2007; 1106.
4. Netter FH. Back and spinal cord. In: Netter FH, ed. Atlas of human anatomy. Summit, New Jersey: The Ciba-Geigy Corporation, 1989:145–55.
5. Netter FH. Abdomen postero lateral abdominal wall. In: Netter FH, ed. Atlas of human anatomy. Summit, New Jersey: The Ciba-Geigy Corporation, 989:230–40.
6. Rafi A. Abdominal field block: a new approach via the lumbar triangle. Anaesthesia 2001; 56: 1024-26.
7. McDonnell JG, O'Donnell B, Curley G, Heffernan A, Power C, Laffey JG. The analgesic efficacy of transverses abdominis plane block after abdominal surgery: a prospective randomized controlled trial. Anesth Analg 2007; 104:193–7. 12. Atkinson R, Rushman G
8. McDonnell JG, Curley GCJ, Carney J, et al. The analgesic efficacy of transversus abdominis block after caesarean delivery. Anaesth Analg 2008; 106:186-91.
9. J.L.H. French et al, Case report, International Journal of Obstetric Anesthesia (2009) 18, 52-54 – Transversus Abdominis Plane Block for analgesia after caesarean section in a patient with an intracranial lesion.
10. Randall I M, Costello J, Carvalho J C 2008, Transversus abdominis plane block in a patient with debilitating pain from an abdominal wall hematoma following Cesarean delivery. Anesth Analg 106: 1928.
11. D. Belavy, P. J. Cowlishaw, M. Howes and F. Phillips, Ultrasound-guided transversus abdominis plane block for analgesia after Caesarean delivery. British Journal of Anaesthesia 103 (5): 726–30 (2009)
12. Meaghan A. Paganelli1 and XGabriela K. Popescu.Actions of Bupivacaine, a Widely Used Local Anesthetic, on NMDA Receptor Response.The Journal of Neuroscience, January 14, 2015 • 35(2):831– 842
13. Sirvinskas E, Laurinaitis R. Use of magnesium sulfate in anesthesiology. Medicina (Kaunas) 2002;38:695-8.
14. Agrawal A, Agrawal S, Payal YS. Effect of continuous magnesium sulfate infusion on spinal block characteristics: A prospective study. Saudi J Anaesth 2014;8:78-82
15. Telci L, Esen F, Akcora D, Erden T, Canbolat AT, Akpir K. Evaluation of effects of magnesium sulphate in reducing intraoperative anaesthetic requirements. Br J Anaesth 2002;89:594-8.
16. Koinig H, Wallner T, Marhofer P, Andel H, Hörauf K, Mayer N. Magnesium sulfate reduces intra- and postoperative analgesic requirements. Anesth Analg 1998;87:206-10.
17. Panda NB, Bharti N, Prasad S. Minimal effective dose of magnesium sulfate for attenuation of intubation response in hypertensive patients. J Clin Anesth 2013;25:92-7
18. Do SH. Magnesium: A versatile drug for anesthesiologists. Korean J Anesthesiol 2013;65:4-8
19. G. S. de Oliveira, L. J. S. Castro-Alves, S. Ahmad, M. C. Kendall, and R. J. McCarthy, "Dexamethasone to prevent postoperative nausea and vomiting: an updated meta-analysis of randomized controlled trials," Anesthesia and Analgesia, vol. 116, no. 1, pp. 58–74, 2013.
20. N. H. Waldron, C. A. Jones, T. J. Gan, T. K. Allen, and A. S. Habib, "Impact of perioperative dexamethasone on postoperative analgesia and side-effects: systematic review and meta-analysis," British Journal of Anaesthesia, vol. 110, no. 2, pp. 191–200, 2013.
21. G. S. de Oliveira, S. Ahmad, P. C. Fitzgerald et al., "Dose ranging study on the effect of preoperative dexamethasone on postoperative quality of recovery and opioid consumption after ambulatory gynaecological surgery," British Journal of Anaesthesia, vol. 107, no. 3, pp. 362–371, 2011.
22. E. Yilmaz-Rastoder, M. S. Gold, K. A. Hough, G. F. Gebhart, and B. A. Williams, "Effect of adjuvant drugs on the action of local anesthetics in isolated rat sciatic nerves," Regional Anesthesia and Pain Medicine, vol. 37, no. 4, pp. 403–409, 2012.
23. Ra YS, Kim CH, Lee GY, Han JI. The analgesic effect of the ultrasound-guided transverse abdominis plane block after laparoscopic cholecystectomy. Korean J Anesthesiol 2010;58:362-8.
24. Petersen PL, Stjernholm P, Kristiansen VB, Torup H, Hansen EG, Mitchell AU, et al. The beneficial effect of transversus abdominis plane block after laparoscopic cholecystectomy in day-case surgery: A randomized clinical trial. Anesth Analg 2012;115:527-33.
25. Chen CK, Tan PC, Phui VE, Teo SC. A comparison of analgesic efficacy between oblique subcostal transversus abdominis plane block and intravenous morphine for laparascopic cholecystectomy. A prospective randomized controlled trial. Korean J Anesthesiol 2013;64:511-6.
26. El-Dawlatly AA, Turkistani A, Kettner SC, Machata AM, Delvi MB, Thallaj A, et al. Ultrasound-guided transversus abdominis plane block: Description of a new technique and comparison with conventional systemic analgesia during laparoscopic cholecystectomy. Br J Anaesth 2009;102:763-7

27. Dean C, Douglas J. Magnesium and the obstetric anaesthetist. Int J Obstet Anesth 2013;22:52-63.
28. Sirvinskas E, Laurinaitis R. Use of magnesium sulfate in anesthesiology. Medicina (Kaunas) 2002;38:695-8.
29. Herroeder S, Schönherr ME, De Hert SG, Hollmann MW. Magnesium— essentials for anesthesiologists. Anesthesiology 2011;114:971-93.
30. Shabbir PM. Miracle of magnesium sulfate. Indian J Allergy Asthma Immunol 2012;26:14-5.
31. Albrecht E, Kirkham KR, Liu SS, Brull R. Peri-operative intravenous administration of magnesium sulphate and postoperative pain: A metaanalysis. Anesthesia 2013;68:79-90.
32. Buvanendran A, Kroin JS. Useful adjuvants for postoperative pain management. Best Pract Res Clin Anaesthesiol 2007;21:31-49.
33. Goyal P, Jaiswal R, Hooda S, Goyal R, Lal J. Role of magnesium sulphate for brachial plexus analgesia. Internet J Anesthesiol 2008;21:1-5. Available from: https://www.ispub.com/IJA/21/1/9826. [Last cited on 2015 Apr 09].
34. Huynh TM, Marret E, Bonnet F. Combination of dexamethasone and local anaesthetic solution in peripheral nerve blocks: a meta-analysis of randomised controlled trials. Eur J Anaesthesiol 2015; 32:751–758.
35. K Al-Refaey,EM Usama and E Al-Hefnawey. Adding magnesium sulfate to bupivacaine in transversus abdominis plane block for laparoscopic cholecystectomy: A single blinded randomized controlled trial.Saudi J Anaesth 2016 Apr-Jun; 10(2): 187–191.
36. Castillo J, Curley J, Hotz J, Uezono M, Tigner J, Chasin M et al. Glucocorticoids prolong rat sciatic nerve blockade in vivo from bupivacaine microspheres. Anesthesiology 1996; 85:1157–1166
37. Droger C, Benziger D, Gao F, Berde CB. Prolonged intercostals nerve blockade in sheep using controlled-release of bupivacaine and dexamethasone from polymer microspheres. Anesthesiology 1998; 89:969–974.
38. Hala El-Kerdawy. Analgesic requirements for patients undergoing lower extremity orthopedic surgery-The effect of combined spinal and epidural magnesium. Middle East J Anaes 2008 19(5);1013-25
39. Rana, Shelly; Verma, Ravinder Kumar; Singh, Jai; Chaudhary, Sudarshan Kumar; Chandel, Ankita. Magnesium sulphate as an adjuvant to bupivacaine in ultrasound-guided transversus abdominis plane block in patients scheduled for total abdominal hysterectomy under subarachnoid block.Indian Journal of Anaesthesia 60(3):p 174-179, March 2016.
40. Bondok RS, Abd El-Hady AM. Intra-articular magnesium is effective for postoperative analgesia in arthroscopic knee surgery. Br J Anaesth 2006; 97:389–392.