**Dexmedetomidine versus Magnesium Sulfate in Anesthesia for Cochlear Implantation Surgery in Pediatric Patients**

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**Abstract**

**Context:** Cochlear implantation surgery represents a great advance in ENT surgeries. Special anesthetic managements were required to provide bloodless surgical field and monitoring of the facial nerve. **Aims:** We aimed to compare both dexmedetomidine and magnesium sulfate as regards their efficacy in inducing deliberate hypotension and providing better quality of the surgical field during cochlear implantation in pediatrics. **Settings and Design:** Prospective, randomized double-blinded study. **Subjects and Methods:** Forty-six pediatric patients aging 1.5–2.5 years of either sex with American Society of Anesthesiologists physical status classes I and II were randomized into dexmedetomidine (D) group (n = 23) and magnesium sulfate (M) group (n = 23). In the D group, after induction of anesthesia but before the surgery, a bolus dose of 0.4 µg/kg slowly infused over 10 min, then continuous infusion by a rate of 0.4 µg/kg/h until the end of surgery. In M group, after induction of anesthesia but before the surgery, magnesium sulfate 10% (50 mg/kg) was given slowly, then continuous infusion by a rate of 10 mg/kg/h during the whole surgery. Intraoperative hemodynamics, quality of surgical field, fentanyl consumption, blood loss, operative time, FLACC pain scores, and adverse effects were compared in both groups. **Statistical Analysis Used:** Data were presented as mean ± standard deviation, ranges, numbers, and percentages as appropriate. Comparison of demographic data and time of surgery was done by Student’s t-test. Two-way analysis of variance with correction for repeated measurements was used for heart rate and blood pressure comparison. Mann–Whitney U-test was used for nonparametric measurements. **Results:** Surgical field score and blood loss were better in D group than M group. Fentanyl consumption was less in D group than M group. Heart rate and mean arterial blood pressure were lower in D group except in the initial times than M group. **Conclusions:** In our study, both drugs were effective in achieving hypotensive anesthesia in pediatrics; however, dexmedetomidine proved to have superior effect on the surgical field and blood loss compared to magnesium sulfate with no intra- and post-operative complications for cochlear implantation surgery.

**Keywords:** Cochlear implantation surgery, controlled hypotension, dexmedetomidine, magnesium sulfate

**INTRODUCTION**

Surgery for cochlear implantation represents a great therapeutic hope for children with irreversible hearing loss and deaf-mutism.\(^1\) Hence, it is considered one of the greatest advances in ENT surgery. On the other hand, anesthesia for cochlear implantation represents a great challenge as the anesthesiologist greatly involved in all surgical steps. It needs special anesthetic management such as providing bloodless surgical field, adequate airway management, limited use of muscle relaxation to facilitate assessment of facial nerve by peripheral nerve stimulator, adequate head positioning to avoid venous congestion which may obscure the surgical field, and finally, smooth recovery without nausea and vomiting and with adequate analgesia.\(^2\)

Controlled hypotension is commonly used to provide bloodless surgical field and optimize visualization for the surgeon which can be achieved by combination of physical techniques and pharmacologic agents such as inhalational anesthetics, opioids, vasodilators, beta blockers, magnesium Sulfate, and \(\alpha_2\) adrenergic agonists.\(^3,4\) The use of controlled hypotension in pediatric surgery was first reported in 1953, thereafter, widely used in various pediatric surgical procedures, including scoliosis surgery, vascular surgery, and neurosurgery.\(^5\)

Dexmedetomidine is \(\alpha_2\) selective and \(\alpha_2\)-adrenoceptor agonist, which inhibits noradrenaline release and decreases sympathetic activity. It can augment anesthesia by providing dose-related sedation, anxiolysis without respiratory depression, decreased

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Magnesium sulfate is a noncompetitive N-methyl d-aspartate receptor antagonist with antinociceptive effects. It acts as a cell membrane stabilizer through the inhibition of Ca-ATPase and Na–K-ATPase involved in transmembrane ion exchange leading to membrane stabilization.[8]

Moreover, it has a vasodilator action by increasing the synthesis of prostacyclin and inhibiting angiotensin-converting enzyme activity; so, it may be a good agent for controlled hypotension.[8]

To the best of our knowledge, no studies available comparing both dexmedetomidine and magnesium sulfate for cochlear implantation in children.

**Aim of work**

The main objective of our study was to compare both dexmedetomidine and magnesium sulfate as regards their efficacy in inducing deliberate hypotension and providing better quality of the surgical field during cochlear implantation. Furthermore, the effect of both drugs on postoperative pain and recovery time was compared.

**Subjects and Methods**

This study was a prospective, randomized, blind study that conducted at Kasr El-Ainy Hospital, Cairo University, from November 2012 to May 2015, after approval of Ethical Committee. Informed consents were obtained from children guardians. Forty-six pediatric patients aging 1.5–2.5 years of either sex with American Society of Anesthesiologists (ASA) physical status classes I and II scheduled for cochlear implant surgery were included in the study. Patients refused to share or with known allergy to magnesium sulfate or dexmedetomidine; also, patients with fever, upper respiratory tract infection, coagulopathy, renal, hepatic diseases, or congenital heart diseases were excluded from the study. The randomization was performed using closed envelopes indicating the group of each patient.

All patients were preoperatively assessed by history, physical examination, and routine investigations (complete blood count, prothrombin time, partial thromboplastin time, International Normalized Ratio, urea, creatinine, serum glutamic pyruvic transferase, serum glutamic oxaloacetic transaminase, albumin, bilirubin, and serum electrolytes). Cardiological consultation and preoperative electrocardiogram were done. Careful assessment of the airway was done. Solid food was not allowed 6 h before surgery but clear fluids were given for up to 2 h preoperatively. Children were randomized into dexmedetomidine (D) group \( (n = 23) \) and magnesium sulfate (M) group \( (n = 23) \).

Monitors were applied: Precordial stethoscope, non-invasive automatic blood pressure, pulse oximeter, and electrocardiograph. Peripheral nerve stimulator was used to assess recovery from muscle relaxant and to monitor the facial nerve intraoperatively. Induction of anesthesia was done by sevoflurane 8%. 0.1 mg/kg; intravenous (i.v.) dexamethasone was given to prevent postoperative nausea and vomiting. Then, after loss of consciousness, an intravenous line was inserted. Fluids were given at 10 ml/kg dextrose saline. Orotracheal intubation was facilitated by atracurium 0.5 mg/kg and fentanyl 1 µg/kg; no maintenance doses of atracurium were given to allow facial nerve monitoring. Arterial catheter was inserted in the radial artery for measurement of invasive blood pressure. Foley catheter was used to decompress the urinary bladder and to monitor urine output. In the D group, after induction of anesthesia but before the surgery, a bolus dose of 0.4 µg/kg slowly dexmedetomidine (Precedex; Abbott Laboratories, North Chicago, Illinois, USA) infused over 10 min, then continuous infusion by a rate of 0.4 µg/kg/h until the end of surgery. In M group, after induction of anesthesia but before the surgery, magnesium sulfate 10% (50 mg/kg) was given slowly, then continuous infusion by a rate of 10 mg/kg/h during the whole surgery. The drugs were prepared and given by anesthesiologist blinded to the study.

Anesthesia was maintained using a 100% O₂ and with 2% sevoflurane. Controlled ventilation was started to maintain normocapnia (35–40 mmHg). Body core temperature was measured by oropharyngeal temperature probe and maintained between 36°C and 37°C using heated mattress and warm intravenous fluids at room temperature. Anesthesia was maintained with continuous infusion of the tested drugs. The target blood pressure was a decrease in blood pressure to get the mean atrial blood pressure (MAP = 50–60 mmHg). If the MAP increased above the target or tachycardia as well, an additional dose of fentanyl was given 1 µg/kg to control these changes. Bradycardia was treated with 0.02 mg/kg i.v. atropine if the heart rate (HR) was 15% lower than the baseline value. After completion of surgery, inhalational anesthesia was stopped and muscle relaxant was reversed with atropine and neostigmine and the patient allowed to breathe spontaneously. The ETT was removed in deep plane of anesthesia to prevent coughing, bucking, and sudden agitation which can displace the implant and the children were transferred to postanesthesia care unit (PACU).

**Measurements**

1. Demographic data were recorded including age, sex, and weight
2. HR and MAP. These data were recorded before induction (baseline), 1 min after intubation then every 10 min till the end of the operation and up to 30 min in PACU
3. Total dose of fentanyl
4. Blood loss and the operative time
5. Quality scale:
   - The surgeon who was blinded of the selected hypotensive agent was asked to assess the quality of the surgical field according to the quality scale proposed by Fromme et al.[9]
   - 0 = No bleeding

\[ 0 = \text{No bleeding} \]
1 = Slight bleeding – blood evacuation not necessary
2 = Slight bleeding – sometimes blood has to be evacuated
3 = Low bleeding – blood has to be often evacuated. Operative field is visible for some seconds after evacuation
4 = Average bleeding – blood has to be often evacuated. Operative field is visible only right after evacuation
5 = High bleeding – constant blood evacuation is needed. Sometimes, bleeding exceeds evacuation. Surgery is hardly possible.

6. Postoperative analgesia according to FLACC score:
The pain intensity was assisted by a person who was blind to study using FLACC scale [10] (Table 1) graded from 0 to 10 (0 = no pain, 10 = the worst possible pain) in the following times 2, 4, 6, 8, 12, and 18 h after recovery. Diclofenac suppository (12.5 or 25 mg) was given if FLACC was more than 5.

7. Postoperatively, recovery time was recorded for all patients. Recovery time was defined as the period of time from discontinuation of sevoflurane till achieving a modified Aldrete recovery score of at least 9.

8. Postoperative adverse effects as postoperative nausea and vomiting were observed as well as respiratory depression, excessive sedation, and loss of knee jerk.

Statistical analysis
Depending on previous studies that examined the surgical field score with dexmedetomidine and magnesium with means (2.19 vs. 2.8) and standard deviation (SD) (0.8 vs. 0.4), and applying these data to G power program with alpha error 0.05 and power 90% using unpaired t-test. The sample size will be 15 in each group that rolled up to 17 in each group for possible dropout. Data were presented as mean ± SD, ranges, numbers, and percentages as appropriate. Comparison of demographic data and time of surgery was done by Student’s t-test. Two-way analysis of variance with correction for repeated measurements was used for HR and blood pressure comparison. Mann–Whitney U-test was used for nonparametric measurements including quality of surgical field and pain score. P <0.05 was considered statistically significant.

RESULTS
Forty-six patients ASA physical status classes I and II were included in the study and were divided into 23 patients in each group. All patients completed the study.

There was no statistically significant difference between both groups regarding the patients’ demographic data and operative time [Table 2].

As regards HR values, HR was significantly lower in all times except the initial stage till 30 min intraoperative in D group as compared to M group. P <0.05 [Figure 1] while MAP values were significantly lower in all times (P <0.001) except the initial stages till 30 min intraoperatively and in PACU in D group as compared to M group [Figure 2]. Moreover, the values of both HR and MAP were decreased in both groups after infusion of the drugs than the baseline values.

The quality of the surgical field intraoperatively was significantly better in dexmedetomidine group as well as the blood loss was significantly less in D group [Table 3].

As regards fentanyl consumption, total dose of the fentanyl used intraoperatively was lower in D group than M group [Table 4].

As regards FLACC score, it was lower in D group than M group with no significant differences [Table 5].

<p>| Table 1: Face, legs, activity, cry, consolability pain score |
|---------------------------------|-----------------|-----------------|</p>
<table>
<thead>
<tr>
<th>Criteria</th>
<th>Score 0</th>
<th>Score 1</th>
<th>Score 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Face</td>
<td>No particular expression or smile</td>
<td>Occasional grimace or frown, withdrawn, uninterested</td>
<td>Frequent to constant quivering chin, clenched jaw</td>
</tr>
<tr>
<td>Legs</td>
<td>Normal position or relaxed</td>
<td>Uneasy, restless, tense</td>
<td>Kicking or legs drawn up</td>
</tr>
<tr>
<td>Activity</td>
<td>Lying quietly, normal position, moves easily</td>
<td>Squirming, shifting, back and forth, tense</td>
<td>Arched, rigid, or jerking</td>
</tr>
<tr>
<td>Cry</td>
<td>No cry (awake or asleep)</td>
<td>Moans or whimpers, occasional complaint</td>
<td>Crying steadily, screams or sobs, frequent complaints</td>
</tr>
<tr>
<td>Consolability</td>
<td>Content, relaxed</td>
<td>Reassured by occasional touching, hugging or being talked to, distractible</td>
<td>Difficult to console or comfort</td>
</tr>
</tbody>
</table>

Figure 1: Heart rate values between two studied group. Data expressed as mean ± standard deviation. P < 0.05* statistically significant. T1 baseline, T2 after intubation, T3 10 min, T4 20 min, T5 30 min, T6 40 min, T7 50 min, T8 60 min, T9 70 min, T10 80 min, T11 90 min, T12 at PACU, T13 15 min PACU, T14 30 min PACU
Table 2: Demographic data and operative time

<table>
<thead>
<tr>
<th></th>
<th>M group (n=23)</th>
<th>D group (n=23)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>2.17±1.61</td>
<td>2.91±1.62</td>
<td>0.567</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>24.19±5.32</td>
<td>22.23±4.44</td>
<td>0.156</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>12 (52.17)</td>
<td>11 (52.17)</td>
<td>0.500</td>
</tr>
<tr>
<td>Female</td>
<td>11 (47.82)</td>
<td>12 (52.17)</td>
<td>0.500</td>
</tr>
<tr>
<td>Operative time (min)</td>
<td>113.88±26.4</td>
<td>117.53±25.6</td>
<td>0.615</td>
</tr>
</tbody>
</table>

Data expressed as mean±SD and n (% from total).

Table 3: Comparison between dexmedetomidine group and M group as regards quality scale for surgical field intraoperatively and blood loss

<table>
<thead>
<tr>
<th></th>
<th>M group (n=23)</th>
<th>D group (n=23)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality scale</td>
<td>2.84±0.74</td>
<td>2.29±0.60</td>
<td>0.01*</td>
</tr>
<tr>
<td>Blood loss (ml)</td>
<td>100±35</td>
<td>60±12.5</td>
<td>0.001*</td>
</tr>
</tbody>
</table>

Data expresses as mean±SD. *Statistically significant (P<0.05). SD=Standard deviation

Table 4: Intraoperative fentanyl consumption and recovery scores

<table>
<thead>
<tr>
<th></th>
<th>M group (n=23)</th>
<th>D group (n=23)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fentanyl doses (µg/kg)</td>
<td>2.65±0.11</td>
<td>1.43±0.43</td>
<td>0.01*</td>
</tr>
<tr>
<td>Modified Aldrete scores (min)</td>
<td>9.11±5.47</td>
<td>9.5±3.48</td>
<td>0.95</td>
</tr>
</tbody>
</table>

Data expresses as mean±SD. *Statistically significant (P<0.05). SD=Standard deviation

Table 5: Face, legs, activity, cry, consolability scores postoperative in both groups

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>M group (n=23)</th>
<th>D group (n=23)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1.05±0.80</td>
<td>1.0±0.84</td>
<td>0.57</td>
</tr>
<tr>
<td>4</td>
<td>3.37±0.45</td>
<td>3.17±0.59</td>
<td>0.64</td>
</tr>
<tr>
<td>6</td>
<td>4.2±0.86</td>
<td>4.03±0.62</td>
<td>0.95</td>
</tr>
<tr>
<td>8</td>
<td>4.4±0.65</td>
<td>3.8±0.85</td>
<td>0.58</td>
</tr>
<tr>
<td>12</td>
<td>5.8±1.05</td>
<td>5.05±0.86</td>
<td>0.6</td>
</tr>
<tr>
<td>18</td>
<td>4.4±0.80</td>
<td>4.30±0.60</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Data expressed as mean±SD. Nonsignificant (P>0.05). SD=Standard deviation

Regarding recovery (modified Aldrete score), it was slightly longer in D group than in Mg group (P > 0.05) with no significant difference [Table 4].

None of our patients experienced loss of knee jerk, respiratory depression (PSO₂ <92%), and excessive sedation. Only 2 patients in D group and 4 patients in M group experienced nausea and vomiting.

**Discussion**

In our study, the quality of the surgical field was significantly better in dexmedetomidine group; also, blood loss was mild in dexmedetomidine group (100 ± 35 vs. 60 ± 12.5 ml) P = 0.001. The intraoperative hemodynamic parameters (MAP and HR) in D group were significantly lower except in initial stages up to 30 min intraoperative and PACU as regards MAP compared to M group but was within 20% lower from baseline values. Fentanyl consumption was significantly lower in D group than M group (1.43 ± 0.43 vs. 2.65 ± 0.11 P = 0.01). Our study also stated that dexmedetomidine had shorter recovery time than M group. Although FLACC pain scores were lower in D group than M group in all measurements, yet it was statistically insignificant (P > 0.05).

Dexmedetomidine is α₂ selective and α₁-adrenoceptor agonist, inhibits noradrenaline release and decreases sympathetic activity. It can augment anesthesia by providing dose-related sedation, anxiolysis without respiratory depression, decreased upper airway secretions, perioperative hemodynamic stability, and analgesia.[6,7] Its clinical applications in children include premedication, prevention of emergence delirium, as part of multimodal anesthetic regimen, and sedation in the pediatric intensive care unit.[11,12]

Magnesium sulfate is a noncompetitive N-methyl d-aspartate receptor antagonist with antinoceptive effects. It acts as a cell membrane stabilizer through the inhibition of Ca-ATPase and Na-K-ATPase involved in transmembrane ion exchange leading to membrane stabilization.

Moreover, it has a vasodilator action by increasing the synthesis of prostacyclin and inhibiting angiotensin-converting enzyme activity, so it may be a good agent for controlled hypotension.[9]

The use of controlled hypotension in pediatric surgery was first reported in 1953; thereafter, widely used in various pediatric surgical procedures, including scoliosis surgery, vascular surgery, and neurosurgery.[9]

Although the use of dexmedetomidine was limited in pediatrics, several studies had used it with clinically acceptable results as regards intraoperative HR and MAP in pediatric age group.[13,14]

El Saied et al. found that dexmedetomidine infusion in cochlear implantation in pediatric patients was better in inducing deliberate hypotension and providing better quality scale of surgical field compared to fentanyl infusion. It allowed rapid
recovery from anesthesia and reduced need for pain medication in the PACU.\cite{15} These findings correlate with the present study.

Furthermore, in agreement with our results, Akkaya et al.\cite{16} in 2014, conducted a randomized clinical study on 60 patients scheduled for functional endoscopic sinus surgery to evaluate the role of dexmedetomidine (1 µg/kg loading dose 10 min before induction of anesthesia followed by 0.6 µg/kg/h infusion) and magnesium sulfate (50 mg/kg loading dose 10 min before induction of anesthesia followed by 15 mg/kg/h infusion) in the amount of bleeding and quality of vision of the surgical field during the operation, and they found that dexmedetomidine provided better visual quality of surgical field and reduced bleeding in surgical field compared with magnesium sulfate, with little or no side effects.

Furthermore, it goes with Mohamed et al.\cite{17} Patients in the dexmedetomidine group (D) (n = 30) received a loading dose of 1 µg/kg of dexmedetomidine in 200 ml of normal saline 0.9% and subsequent doses of 0.5 µg/kg/h, whereas patients in the magnesium sulfate group (Mg) (n = 30) received a loading dose of 50 mg/kg of magnesium sulfate in 200 ml of normal saline 0.9% and subsequent maintenance doses at 15 mg/kg/h in adults undergoing middle ear surgery. They found that according to IOSFE scale, the surgical field was better with dexmedetomidine group than magnesium sulfate group.

In our study, total fentanyl consumption was significantly lower in dexmedetomidine group than Mg sulfate group (1.43 ± 0.43 vs. 2.65 ± 0.11, P = 0.01) coinciding with the results of Dikmen et al.\cite{18,19} and Ibraheim et al.\cite{20} who stated that fentanyl and propofol consumption were significantly lower in the dexmedetomidine group compared with the esmolol and control groups.

Our study goes with Akkaya et al. who found hemodynamics was significantly lower in dexmedetomidine than milligram group during functional endoscopic sinus surgery (FESS) except in the initial stages. Secondary decrease in the HR and blood pressure due to the inhibiting effects of dexmedetomidine on central sympathetic stimulus and stimulation of the peripheral α, adrenoceptors in vascular smooth muscle tissue are considered to be responsible for this situation.\cite{16}

Furthermore, in agreement with our hemodynamic findings, El Saied et al. found that dexmedetomidine showed a significant reduction in intraoperative HR and MAP more than fentanyl. Moreover, the intraoperative reduction in hemodynamic parameters (MAP and HR) in both groups was within 20% from baseline values.\cite{15}

Recovery time in dexmedetomidine group was not prolonged in both groups in spite of sedative effects. This was explained by the reduction of intraoperative anesthetic requirements. Moreover, sedation of dexmedetomidine is easily to be aroused. This is meeting the findings of Gupta et al.\cite{20} who studied the effect of dexmedetomidine on achieving oligeic field for middle ear surgery and found that dexmedetomidine did not affect awakening time or delayed recovery from anesthesia.

In contrast to our study, Blow et al.\cite{21} concluded that dexmedetomidine provided a prolonged recovery time than remifentanil group in patients undergoing invasive video gynecologic surgical procedures. This was explained as remifentanil has an elimination half-life of 7 min and degradation is done by blood and tissue esterase. Hence, remifentanil infusion does not cause overhanging effects and is much shorter than fentanyl.

In our study, nausea and vomiting had a higher incidence in Mg group than D group but no significant statistically difference coinciding with the results of Mohamed et al.\cite{17} and Ali et al.\cite{22} who reported the incidence of postoperative nausea and vomiting was less in pediatric patients receiving dexmedetomidine in comparison with those receiving fentanyl during extracorporeal shock wave lithotrypsy, the same findings reported with Turgut et al.\cite{23} during lumbar laminectomy in adults meeting with our results.

In our study, FLACC pain scores showed no significant difference between both groups meeting the results of El Saied et al.\cite{15}

Limitations of our study
there was no controlled group as it is unethical in hypotensive anesthesia. Furthermore, postoperative magnesium sulfate was not measured but no patients exhibited signs of excessive neuromuscular blocks. Another limitation is we used a subjective scoring for surgical field assessment. We did not report intraoperative inhalational consumption.

We recommend to use both drugs in smaller age group in more prolonged surgeries to detect safety and complications.

Conclusions
in our study, both drugs were effective in achieving hypotensive anesthesia in pediatrics; however, dexmedetomidine proved to have superior effect on the surgical field and blood loss compared to magnesium sulfate with no intra- and post-operative complications.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

References


