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INCIDENCE AND MANAGEMENT OF PENILE ERECTION DURING ANESTHESIA IN PEDIATRIC PATIENTS: A STUDY ON THE EFFICACY OF DEXMEDETOMIDINE

Uttam Kumar Patel[1], Karan Kaushik[2], Mohd. Imran[3], Amrendra Kumar Jha[4], Akanksha Chowdhary[5]

[1]Department of Anaesthesia Critical Care Heritage Hospitals Varanasi, Nagwa Lanka, Varanasi, Uttar Pradesh, India.
[2]Department of Cardiac Anaesthesia, King George's Medical University Shah Mina Rd, Chowk, Lucknow, Uttar Pradesh, India.
[3]Department of Anaesthesia Career Medical College VVHX+86Q, Muftiganj Daulatganj Rd, Abbas Nagar, Muftiganj, Daulatganj, Lucknow, Uttar Pradesh, India.
[4]Department of Critical Care, Apollomedics Super Speciality Hospitals Kanpur - Lucknow Rd, Sector B, Bargawan, LDA Colony, Lucknow, Uttar Pradesh, India.
[5]Department of Hospital Administration, Banaras Hindu University Lanka, Varanasi, Uttar Pradesh, India.

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Corresponding Author:
Dr. Karan Kaushik,
Department of Cardiac Anaesthesia, King George's Medical University Shah Mina Rd, Chowk, Lucknow, Uttar Pradesh, India.
Email: kaushikkaran18@gmail.com

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ABSTRACT

Background: Intraoperative penile erection during anesthesia is a significant complication that can disrupt surgical procedures, especially in pediatric patients. Dexmedetomidine, a selective alpha-2 adrenergic agonist, has been proposed as a solution due to its sedative and sympatholytic properties, but limited studies have evaluated its effectiveness in preventing and treating penile erection during pediatric surgeries. **Aim:** To evaluate the role of intravenous dexmedetomidine for prevention and treatment of intraoperative penile erection in pediatric patients.

Material and Methods: The study involved male patients aged 1-14 with ASA grade I or II who underwent elective non-urological procedures. Patients were divided into three groups: Group I received no dexmedetomidine, Group II received 0.5 µg/kg dexmedetomidine preoperatively, and Group III received 0.5 µg/kg dexmedetomidine if a penile erection occurred intraoperatively. Hemodynamic parameters were recorded at baseline and throughout surgery, and post-operative sedation was monitored using the Ramsay Sedation Score.

Results: Intraoperatively, 16.7% of patients in Group I had an erection of the penis, 0% in Group II and 100% in Group III. After treatment, only 3.15% of patients in Group III had a sustained penile erection. Significant differences in postoperative pain scores were observed, with Group I showing increased scores at all-time intervals compared to Group II and Group III ($p < 0.001$). The occurrence of problems, including bradycardia and hypotension, was similar in Groups II and III ($p > 0.05$), but slightly increased in Group III.

Conclusion: Dexmedetomidine is effective in preventing and managing penile erections in pediatric patients undergoing non-urological surgeries. Preoperative administration reduces penile erection incidence and provides post-operative pain management. However, caution is advised due to potential bradycardia and hypotension risks.

Keywords: Dexmedetomidine, Intraoperative Penile Erection, Pediatric Anesthesia, Post-Operative Pain, Ramsay Sedation Score.

INTRODUCTION

Paediatric patients' penile erections during anaesthesia pose a special challenge to the fields of surgery and anesthesiology.[1,2] Though the phenomenon in adults is fairly well-documented, especially during spinal and epidural anaesthesia, its occurrence in children is still poorly understood. In particular, penile erections during urogenital, abdominal, and pelvic surgeries can complicate the

procedure and cause delays, cancellations, or the need for additional interventions.[3] The purpose of this study is to ascertain the prevalence of penile erections in paediatric patients under anaesthesia and assess the effectiveness of dexmedetomidine as a management tactic.

The true incidence of penile erections during anaesthesia in paediatric populations is likely underreported, as these conditions are frequently transient and may resolve spontaneously before being documented. According to studies, the incidence of penile erections during anaesthesia in paediatric populations varies significantly, with reported rates ranging from 0.1% to 3.5%.[3,4] The true incidence is influenced by several factors, including the patient's age, type of surgery, and the anaesthetic agents used.

The intricate physiological process of penile erection is governed by the interaction of vascular, hormonal, and neuronal elements. It's mostly handled by the parasympathetic nervous system, which causes the corpora cavernosa's smooth muscles to relax, increasing blood flow and erection. Penile erections may result from some anaesthetic drugs that upset the balance between sympathetic and parasympathetic inputs.[5,6]

An erection can be made easier by anaesthetics like ketamine and inhalational anaesthetics, which have been shown to increase parasympathetic activity or decrease sympathetic tone. Furthermore, parasympathetic activity can be unopposed by spinal and epidural anaesthesia, which blocks sympathetic output. Penile erections under anaesthesia are a common occurrence in paediatric patients due to autonomic dysregulation being exacerbated by psychosocial variables including worry and anxiety prior to surgery.[7]

The selective alpha-2 adrenergic agonist dexmedetomidine has shown promise as a medication for controlling penile erections during anaesthesia. Guler et al. reported that In 12 out of almost 7,800 patients, an endoscopic treatment resulted in a penile erection. Three patients underwent general anaesthesia, one underwent epidural anaesthesia, and eight underwent spinal anaesthesia. The operating urologist assessed the stiffness of the erection. Normal saline was used to dilute dexmedetomidine to a concentration of 4 µg/ml. Intravenous injections of 0.5 µg/kg dexmedetomidine were administered in each patient. In our institution, the incidence of intraoperative penile erection under general anaesthesia was 0.34%, that of spinal anaesthesia was 0.11%, and that of epidural anaesthesia was 1.72%. After receiving a single intravenous dose of dexmedetomidine (83%), detumescence was attained in 9 patients during the first 5 minutes and in 1 patient at the 9th minute. After fifteen minutes, two patients (17%) showed no signs of detumescence. Because of its sedative, anxiolytic, and analgesic pharmacological nature, it is very helpful for treating paediatric patients.[8]

By attaching itself to alpha-2 adrenoceptors in the peripheral and central nervous systems, dexmedetomidine reduces sympathetic outflow and increases parasympathetic activity.[9]

Research has indicated that in paediatric patients, dexmedetomidine successfully reduces psychogenic triggers of penile erection while also providing drowsiness and anxiolysis. Moreover, penile detumescence is promoted by its sympatholytic actions, which counterbalance autonomic dysregulation brought on by anaesthesia. With a good safety profile and few adverse effects, clinical investigations have demonstrated the potential advantages of dexmedetomidine in treating and preventing penile erections during anaesthesia.

MATERIALS AND METHODS

This study included male patients aged 1-14 years who underwent elective, non-urological procedures under general anaesthesia and had ASA grade I or II; patients taking analgesics, steroids or α2-adrenergics and patients who were allergic to the study drug were not included in the study.

Patients in the study received premedication with midazolam and atopine, anaesthesia with sodium thiopentone and succinylcholine, and intravenous infusions of Isolyt P or balanced salt solution. Isoflurane, atracurium besylate and 60% N2O in O2 were used as non-depolarizing muscle relaxants to maintain anaesthesia.

Patients were categorised into one of the following groups: Group I patients were enrolled for surgery under general anaesthesia, Group II patients received 0.5 µg/kg dexmedetomidine i.v. preoperatively, and Group III patients received 0.5 µg/kg dexmedetomidine i.v. only if penile erection occurred intraoperatively.

Patients' hemodynamic parameters were recorded at baseline, during and after surgery, assessed by the surgeon and subsequently reversed, extubated and transferred to the paediatric intensive care unit.

The patient's sedation was monitored hourly for up to 24 hours using the Ramsay Sedation Score. Postoperative pain was assessed using the VAS score, and if ≥4, a rectal paracetamol suppository was administered. Complications/side effects such as nausea, vomiting, pruritus, hypotension, bradycardia, sedation and respiratory depression were recorded.

RESULTS

Table 1 shows the demographic and clinical characteristics of patients in Group I, Group II, and Group III. The age ($F = 2.587$, $p = 0.081$), weight ($F = 3.033$, $p = 0.053$), and length of surgery ($F = 1.518$, $p = 0.225$) were not statistically significant differences in between groups. Moreover the distribution of patients according to ASA grade I/II

classifications was not significant different between groups. [Table 1]

Penile erection was not detected in any group before surgery. After the start of surgery, penile erection was found in 16.7% in group I, 0.0% in group II and in all patients (100%) in group III. After treatment, penile erection was found in only 3.158% of group III. In addition, penile erection was significantly more frequent in group III than in group II and group I after the start of surgery. [Table 2]

Table 3 compares mean ± SD values for Groups I, II, and III at various time periods. The mean ± SD values at 1 hour are 2.77 ± 0.43 for Group I, 4.79 ± 0.77 for Group II, and 5.33 ± 0.71 for Group III. Group I: 2.57 ± 0.50, Group II: 4.38 ± 0.82, and Group III: 4.47 ± 0.82 at 2 hours. At 3 hours, Group I had 2.33 ± 0.48, whereas Group II and III have 4.00, with standard deviations of ± 0.60 and ± 0.64, respectively. At 4 hours, Group I is at 2.13 ± 0.43, Group II at 3.59 ± 0.68, and Group III at 3.60 ± 0.50. The results at 8 hours are 1.97 ± 0.32 for Group I, 3.31 ± 0.60 for Group II, and 3.23 ± 0.57 for Group III. At the 12-hour point, Group I is 1.83 ± 0.38, Group II 2.93 ± 0.70, and Group III 2.83 ± 0.53. At 16 hours, Group I had 1.70 ± 0.47, whereas Group II and III have 2.45 ± 0.57 and 2.40 ± 0.56, respectively. Group I: 1.53 ± 0.51, Group II: 2.17 ± 0.60, and Group III: 2.20 ± 0.41 at 20 hours. The mean ± SD values at 24 hours are 1.30 ± 0.47 for Group I, 1.83 ± 0.66 for Group II, and 1.97 ± 0.56 for Group III. At all time periods, the p-values are <0.001, showing significant group differences. [Table 3]

Table 4 compares post-operative pain ratings (Mean ± SD) at various time intervals for Groups I, II, and III. Post-op scores showed significant differences between Group I (4.50 ± 0.90), Group II (1.93 ± 0.64), and Group III (1.30 ± 0.47, p-value <0.001). Group I reported 3.47 ± 0.68, Group II 2.67 ± 0.55, and Group III 1.83 ± 0.38 at 4 hours, all with p-value <0.001. At 12 hours, Group I scored 2.67 ± 0.61, Group II 3.10 ± 0.55, and Group III 2.30 ± 0.53, a significant difference (p <0.001). Group I reported 2.17 ± 0.46, Group II 3.47 ± 0.57, and Group III 2.83 ± 0.59 at 18 hours (p <0.001). At 24 hours, Group I scored 1.80 ± 0.48, Group II 3.67 ± 0.80, and Group III 3.30 ± 0.60, differing significantly at all time intervals (p-value <0.001). [Table 4]

Table 5 shows Dexmedetomidine-related problems in pediatric patients in Groups II and III. Complication rates are based on 30 patients per group. The chi-square test showed no significant differences in the incidence of specific complications between Groups II and III, including bradycardia, hypotension, pruritus, and sedation (χ^2 = 0.000, p = 1.000, χ^2 = 0.353, p = 0.552, χ^2 = 0.692, p = 0.406, χ^2 = 1.053, These data imply the two groups had comparable adverse event safety profiles. Group III had somewhat more difficulties than Group II (53.3% vs. 43.3%). While not statistically significant, this trend emphasizes the need for careful monitoring and personalized dose of Dexmedetomidine in pediatric anesthesia. Group III's small increase in complications may require additional inquiry into adverse event causes and anesthetic protocol revision to enhance safety and effectiveness in pediatric surgery. [Table 5]

Table 1: Comparison of Age and Body Weight

Parameter	Group I (n=30)		Group II (n=30)		Group III (n=30)		Statistical significance (ANOVA)	
	Mean	SD	Mean	SD	Mean	SD	F	p
Age	3.64	1.90	5.32	3.84	4.20	2.64	2.587	0.081
Weight(kg)	12.60	5.46	17.27	9.25	15.09	6.83	3.033	0.053
Duration of surgery (hr)	2.37	0.47	2.26	0.40	2.18	0.34	1.518	0.225
	N:N		N:N		N:N		Chi sq.	
ASA Grade I/II	20:10		23:7		25:5		χ^2=2.286; p=0.319	

Table 2: Comparison of Events of Penile Erection at different time intervals

Time	Group I (n=30)		Group II (n=30)		Group III (n=30)		Statistical significance	
	No.	%	No.	%	No.	%	χ^2	[1]p
Before surgical intervention	0	0.0	0	0.0	0	0.0	-	-
After start of surgery	5	16.7	0	0.0	30	100	72.458	<0.001*
After treatment	-	-	0	0.0	3	10.0	3.158	0.076

1=Chi-square test, *=Significant (p<0.05)

Table 3: Comparison of Ramsay Sedation Score at different time intervals

Time	Group I (n=30)		Group II (n=30)		Group III (n=30)		[1]p-Value
	Mean	±SD	Mean	±SD	Mean	±SD	
1 hr	2.77	0.43	4.79	0.77	5.33	0.71	<0.001*
2 hr	2.57	0.50	4.38	0.82	4.47	0.82	<0.001*
3 hr	2.33	0.48	4.00	0.60	4.00	0.64	<0.001*
4 hr	2.13	0.43	3.59	0.68	3.60	0.50	<0.001*
8 hr	1.97	0.32	3.31	0.60	3.23	0.57	<0.001*
12 hr	1.83	0.38	2.93	0.70	2.83	0.53	<0.001*
16 hr	1.70	0.47	2.45	0.57	2.40	0.56	<0.001*

20 hr	1.53	0.51	2.17	0.60	2.20	0.41	<0.001*
24 hr	1.30	0.47	1.83	0.66	1.97	0.56	<0.001*

[1=]Kruskal-Wallis test, *=Significant (p<0.05)

Table 4: Comparison of Post-op Pain Score at different time intervals

	Group I (n=30)		Group II (n=30)		Group III (n=30)		1p-Value
	Mean	±SD	Mean	±SD	Mean	±SD	
PO	4.50	0.90	1.93	0.64	1.30	0.47	<0.001*
4 hr	3.47	0.68	2.67	0.55	1.83	0.38	<0.001*
12 hr	2.67	0.61	3.10	0.55	2.30	0.53	<0.001*
18 hr	2.17	0.46	3.47	0.57	2.83	0.59	<0.001*
24 hr	1.80	0.48	3.67	0.80	3.30	0.60	<0.001*

[1=]Kruskal-Wallis test, *=Significant (p<0.05)

Table 5: Comparison of Complications owing to Dexmedetomidine use between Groups II and III

Complications	Group II		Group III	
	No.	%	No.	%
No	17	56.7	14	46.7
Yes	13	43.3	16	53.3
Bradycardia	4	13.3	4	13.3
Hypotension	1	3.3	2	6.7
Pruritus	2	6.7	1	3.3
Sedation	6	20.0	9	30.0

DISCUSSION

Intra-operative penile erection, albeit uncommon, may occur during cystoscopy or other surgical procedures involving the penis under regional or general anesthesia, resulting in either partial or complete erection. When this occurs, it is more problematic to execute the process, as efforts may result in consequences such as severe bleeding, urethral injuries, and need delays or prolongation of the surgery. Anaesthesiologists and urologists should recognize its existence and collaborate to rectify this problem. Conventional therapy approaches for this scenario are not documented in the literature. Numerous pharmacological interventions, both local and systemic, have been documented, including direct intra-cavernous injection of phenylephrine,[10,11] norepinephrine,[12] metaraminol,[13] intravenous ketamine,[14] ephedrine, glycopyrrolate, terbutaline,[14] and salbutamol inhaler.[15]

The suggested therapies for inducing detumescence are not consistently successful. The administration of alpha adrenergic agonists constitutes an effective and swift, but transient, therapeutic intervention. Moreover, repeated intracavernous injections of vasoactive drugs may result in systemic adverse effects, including severe hypertensive crises, pulmonary edema, and potentially fatal outcomes owing to aneurysm rupture.

Dexmedetomidine is a powerful, selective alpha2 agonist that exhibits sedative, analgesic, and anesthetic-sparing properties, while also reducing heart rate, blood pressure, and cardiac output in a dose-dependent manner. Alpha2 agonists lower blood pressure via centrally mediated sympatholytic mechanisms and by reducing norepinephrine release via peripheral presynaptic alpha2 activation. Furthermore, alpha2 agonists elicit peripheral vasoconstriction by directly stimulating vascular smooth muscle alpha2 receptors. Our research assessed the impact of dexmedetomidine on intraoperative penile erection. This study aimed to assess the efficacy of intravenous dexmedetomidine in preventing and treating intraoperative penile erection in pediatric patients.[16]

Guler et al. (2012) investigated the impact of dexmedetomidine on blood pressure and heart rate measured at 1, 5, 10, and 30 minutes post-administration of dexmedetomidine [8]. Dexmedetomidine was seen to substantially reduce systolic blood pressure at the fifth minute (p=0.019), whereas diastolic blood pressure exhibited no significant changes at any time point. The delivery of dexmedetomidine resulted in a substantial reduction in heart rate (p=0.011). Although the decreases in blood pressure and heart rate were statistically significant, the findings remained within normal physiological limits and were clinically insignificant. None of the individuals needed intervention for hypotension or bradycardia.

In our research, we documented the baseline heart rate and blood pressure, as well as measurements at 15, 30, 45, 60, 75, and 90 minutes after dexmedetomidine administration. At baseline, no statistically significant difference was identified among the various groups (p>0.05). Throughout the majority of the intraoperative process, intergroup differences were not statistically significant (p>0.05). Statistically significant differences between groups were seen at 30 minutes, 75 minutes, 90 minutes, and throughout the post-operative period (p<0.05). At all observed intervals, Group I exhibited greater values, while Groups II and III had lower values. No significant changes were seen in systolic, diastolic, or mean arterial blood pressure in any of the groups.

Intraoperative penile erection may occur, irrespective of the kind of anesthesia used, whether regional or general. The reported incidence ranged from 0.1% to 2.4%, mostly affecting younger age groups.[1,17] The occurrence of intraoperative penile erection was 0.34% with general anesthesia, 0.11% with spinal anaesthesia, and 1.72% with epidural anaesthesia. Penile detumescence occurred in 9 individuals during the first 5 minutes and in 1 patient at the 9th minute after the administration of a single intravenous dose of dexmedetomidine (83%). Detumescence was absent in two individuals after 15 minutes (17%). The anesthetic administered to these two individuals was spinal anaesthesia. Spinal block was successfully achieved at the T10 dermatome in one patient and at the T8 dermatome in another.[8]

Our study shows the the incidence of penile erection is around 16.7% (5/30) at our institution. The individuals administered preemptive dexmedetomidine did not have penile erection, although those receiving dexmedetomidine as therapy did. Three (10%) patients do not achieve detumescence. Intraoperative penile erection under anesthesia seems to be reflexively mediated. Local stimulation of the penis seems to stimulate parasympathetic pathways in the sacral spinal cord, resulting in autonomic imbalance. Sympathetic output from the lower thoracic and upper lumbar regions was abolished under regional and general anesthesia. Penile erection is often seen with regional blocks above the T8 level and seldom below the T12 level.[18] It was posited that other nonadrenergic and noncholinergic neuronal mechanisms are implicated, alongside a complex network of local neurotransmitters, including nitric oxide, kinins, and others.[19] Guler et al. (2012) documented Ramsay sedation ratings in individuals administered dexmedetomidine after spinal and epidural anesthesia.[8] The sedation level in six patients, as per the Ramsay sedation score, was recorded at 2. At the three-hour evaluation, none of the patients exhibited profound sedation.

In our study, the Ramsey sedation score was documented throughout the postoperative period for all patients who had surgery under general anesthesia. At all post-operative intervals, the control group exhibited considerably lower sedation ratings than the study groups ($p<0.05$). No statistically significant difference in sedation ratings was seen between the study groups at any post-operative period ($p>0.05$). A significant and sustained reduction in sedation ratings was found across all three groups compared to the one-hour post-operative period. In all three groups, sedation ratings were at their lowest at 24 hours and at their highest at 1 hour post-operatively. None of the patients experienced profound sedation. Numerous therapeutic modalities for intraoperative penile erection have been documented. The majority of these interventions were beneficial, since there have been few recorded case studies involving patients. The predominant medicine used for managing intraoperative penile erection is ketamine, however its effectiveness is inconsistent.[20,21] Conversely, the preemptive administration of dexmedetomidine demonstrated 100% efficacy in our investigation.

Central norepinephrine transmission seems to enhance sexual function, but peripheral effects are adverse. Furthermore, clonidine's suppression of norepinephrine release has been shown to diminish erection and sexual behaviour.[22] Bloor et al. (1992) indicated that dexmedetomidine reduces plasma catecholamine levels and inhibits catecholamine release in response to an unpleasant stimulus at the same dosage used in their research.[24]

Dexmedetomidine is an α2-adrenoreceptor agonist with an affinity eightfold greater than that of clonidine.[25] The primary method by which dexmedetomidine addresses intraoperative penile erections may be attributed to its α2-agonistic properties. Kunisawa et al. (2009) observed in a prior investigation that the administration of an intravenous bolus of dexmedetomidine induced peripheral vasoconstriction within the first minutes, an action attributed to α2-adrenoreceptors.[26] We believe that this impact contributes to the formation of detumescence.

Dexmedetomidine has an anesthetic-sparing action. Numerous clinical investigations indicate that pretreatment with dexmedetomidine decreases the dosage need for the intravenous anesthetic agent thiopental, as well as for opioids, volatile anesthetics, and nondepolarizing neuromuscular blocking drugs.[27,28]

In our study, we observed that the analgesic demand diminishes in the postoperative period for individuals administered dexmedetomidine compared to those who were not. The evaluation for the need of postoperative analgesia was conducted using the VAS pain score method. Guler et al. (2012) found that the occurrence of intraoperative penile erections was reduced with spinal anesthesia compared to general and epidural anaesthesia.[8] In a comparison of dexmedetomidine (0.5µg/kg) for the treatment of penile erection in 6 out of 8 patients under spinal anaesthesia, two individuals exhibited resistance to the therapy, maybe attributable to insufficient dosing. Similarly, 3 out of 30 patients exhibited a failed response to dexmedetomidine treatment in our study; however, the preemptive administration of dexmedetomidine achieved a 100% success rate in preventing intraoperative penile erection in pediatric patients undergoing non-urological surgery under general anesthesia.

CONCLUSION

In conclusion, this study provides comprehensive insights into the incidence and management of penile erection events during anesthesia in pediatric patients, highlighting dexmedetomidine's efficacy in mitigating these events, optimizing sedation levels, and improving post-operative pain management.

The findings underscore the importance of personalized anesthesia protocols and continuous monitoring to achieve optimal clinical outcomes while minimizing complications associated with dexmedetomidine use in pediatric anesthesia practice. Continued research efforts are warranted to further elucidate its pharmacological properties and refine its role in enhancing perioperative care for pediatric patients.

REFERENCES

1. Baltogiannis D, Charalabopoulos A, Giannakopoulos X, Giannakis D, Sofikitis N, Charalabopoulos K (2006) Penile Erection During Transurethral Surgery. Journal of andrology 27:376-380. doi:10.2164/jandrol.05158
2. Hoda W, Xess P, Kumar M, Kindo S, Lakra L (2022) Successful Management of Intraoperative Priapism under General Anesthesia during Transurethral Surgery - A Case Series with Review of Its Management. Anesthesia, essays and researches 16 (1):177-180. doi: 10.4103/aer.aer_61_22
3. Bakan M, Eliçevik M, Bozkurt P, Kaya G (2007) Penile erection during remifentanil anesthesia in children. Paediatric anaesthesia 16:1294-1295. doi:10.1111/j.1460-9592.2006. 02007.x
4. Burnett AL (2020) Rare disorders of penile erection. Fertility and Sterility 113 (1):6-12. doi:https://doi.org/10.1016/j.fertnstert.2019.11.013
5. Rao THSG, Zaman W, Jain R (2001) Intraoperative penile erection. Archivos españoles de urología 53:953-956
6. Sangiorgi G, Cereda A, Benedetto D, Bonanni M, Chiricolo G, Cota L, Martuscelli E, Greco F (2021) Anatomy, Pathophysiology, Molecular Mechanisms, and Clinical Management of Erectile Dysfunction in Patients Affected by Coronary Artery Disease: A Review. Biomedicines 9 (4). doi:10.3390/biomedicines9040432
7. Ma X, Yan J, Jiang H (2023) Application of Ketamine in Pain Management and the Underlying Mechanism. Pain research & management 2023:1928969. doi:10.1155/2023/1928969
8. Guler G, Sofikerim M, Ugur F, Aksu R, Boyaci A (2011) Intravenous dexmedetomidine for treatment of intraoperative penile erection. International urology and nephrology 44:353-357. doi:10.1007/s11255-011-0023-x
9. Giovannitti JA, Jr., Thoms SM, Crawford JJ (2015) Alpha-2 adrenergic receptor agonists: a review of current clinical applications. Anesthesia progress 62 (1):31-39. doi:10.2344/0003-3006-62.1.31
10. Nouri M, Tligui M, Sebe P, Haab F, Gattegno B, Thibault P. Peroperative erection in lower urologic surgery Prog Urol. 2000 Apr; 10(2):303-9.
11. White PF, Way WL, Trevor AJ. Ketamine: its pharmacology and therapeutic uses. Anesthesiology. 1982; 56:119–36.
12. De Meyer JM, De Sy WA. Intracavernous injection of noradrenaline to interrupt erections during surgical interventions. Eur Urol. 1986; 12:169–70.
13. Tsai SK, Hong CY. Intracavernosal metaraminol for treatment of intraoperative penile erection. Postgrad Med J 1990; 66(780): 831-3.
14. Gale AS. Ketamine prevention of penile tumescence. JAMA 1972; 219:1629.
15. Shantha TR. Intraoperative management of penile erection by using terbutaline. Anesthesiology1989; 70:707–9.
16. Prakash S, Sharma S, Miglani S, Gogia AR. Management of intraoperative penile erection with salbutamol aerosol. J Anaesthesiol Clin Pharmacol. 2012 Jul;28(3):402-3.
17. Weerink, M.A.S., Struys, M.M.R.F., Hannivoort, L.N. et al. Clinical Pharmacokinetics and Pharmacodynamics of Dexmedetomidine. Clin Pharmacokinet 2017; 56:893–913.
18. Staerman F, Nouri M, Couerdacier P et al. Treatment of the intraoperative penile erection with intracavernous phenylephrine. J Urol 1995; 153:1478–81.
19. Pertek JP, Coissard A, Artis M. Dorsal nerve block for intraoperative management. Reg Anesth. 1996;21: 491 -92.
20. Sanders KM, Ward SM. Nitric oxide and its role as a non-adrenergic, non-cholinergic inhibitory neurotransmitter in the gastrointestinal tract. Br J Pharmacol. 2019;176(2):212-227.
21. Appadu B, Calder I. Ketamine does not always work in treatment of priapism. Anaesthesia 1991; 46:426–7.
22. Villalonga A, Beltran J, Gomar C, Nalda MA. Ketamine for treatment of priapism. Anest Analg1985; 64:1033–4.
23. Clark JT, Smith ER, Davidson JM. Evidence for the modulation of sexual behaviour by alpha-adrenoceptors in male rats. Neuroendocrinology1985; 41:36-43.
24. Bloor BC, Ward DS, Belleville JP, Maze M. Effects of Intravenous Dexmedetomidine in Humans: II. Hemodynamic Changes. Anesthesiology 1992; 77:1134-42.
25. Maze M, Tranquilli W. Alpha-2 adrenergic agonists: defining the role in clinical anaesthesia. Anesthesiology 1991; 74: 581–605.
26. Kunisawa T, Nagata O, Nagashima M, Mitamura S, Ueno M, Suzuki A, Takahata O, Iwasaki H. Dexmedetomidine suppresses the decrease in blood pressure during anaesthetic induction and blunts the cardiovascular response to tracheal intubation. J Clin Anesth. 2009; 21(3):194-9.
27. Aantaa RE, Kanto JH, Scheinin M, Kallio AM, Scheinin HL. Dexmedetomidine premedication for minor gynecologic surgery. Anaesth Analg 1990; 70:407-13.
28. Memis D, Turan A, Karamanlioglu B, Seker S, Pamukeu Z. Dexmedetomidine reduces rocuronium dose requirement in sevoflurane anaesthesia. Curr Anaesth Crit Care 2008; 19:169-74.