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Dexmedetomidine versus remifentanil infusion for controlled hypotension in shoulder arthroscopy: a comparative study

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Abstract

Study objective: The correct performance of the shoulder arthroscopic technique requires appropriate visualization through a video camera which raises the need for providing satisfactory bloodless surgical field. The current study was conducted to evaluate the clinical efficacy of dexmedetomidine infusion compared to that of remifentanil for controlled hypotension in patients undergoing shoulder arthroscopy.

Patients and methods: Forty patients undergoing elective arthroscopic shoulder surgery under general anesthesia were enrolled in the current study. Patients were randomly distributed into one of two equal groups: dexmedetomidine group (D group) and remifentanil group (R group) according to the agent used for controlled hypotension. In group D, IV dexmedetomidine l μg/kg was infused over 10 min before anesthesia induction, followed by a continuous infusion of 0.3-0.6 μg/kg/h during the operation. In group R, 1 μg/kg remifentanil IV bolus was administered before induction of anesthesia and continued 0.25-0.50 μg/kg/min during the operation. In both groups, the drug infusion was titrated to achieve a mean arterial pressure (MAP) of 60-70 mmHg. Hemodynamic parameters, surgical field condition, recovery profile, and the incidence of perioperative adverse events were assessed.

Results: Controlled hypotension was achieved successfully in both study groups. There was no intergroup significant difference as regards the intraoperative MAP and heart rate (HR) recordings ($P > 0.05$) except for the significantly lower HR recorded after extubation,30 min and 1 h postoperative in group D when compared with group R ($P < 0.05$). The surgical field condition was satisfactory on surgeon assessment in both groups ($P > 0.05$). Extubation time, time to reach modified Aldrete score ≥ 9 and time to 1st postoperative analgesic requirement were significantly longer in the group D when compared with group R ($P < 0.05$). Postoperative Ramsay sedation score recordings were significantly higher in the group D when compared with group R ($P < 0.05$) except at 2 h postoperative recordings and all the VAS score recordings were significantly lower in group D when compared with group R ($P < 0.05$). There was no intergroup significant difference as regards the incidence of perioperative adverse events.

Conclusion: Both remifentanil and dexmedetomidine can induce adequate levels of hypotensive anesthesia and satisfactory surgical field visibility in patients undergoing shoulder arthroscopy under general anesthesia. Patients treated with dexmedetomidine had better quality and more extended postoperative analgesia but longer postoperative anesthesia recovery and higher postoperative sedation scores when compared with remifentanil.

Keywords: Shoulder arthroscopy, Dexmedetomidine, Remifentanil

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Background

Recent surgical advances have resulted in the development of minimal access arthroscopic procedures with resulting improvements in speed of convalescence (Abraham, 2018). Shoulder arthroscopy is a minimal invasive technique that has been performed not only as a diagnostic tool but also therapeutically in a wide range of intra-articular and extra-articular conditions, such as rotator cuff damage (Kim et al., 2015a), labral injury (Sciascia et al., 2015), and biceps tendinopathy (Gombera et al., 2015).

During shoulder arthroscopy, particularly those involving the subacromial space, bleeding is a frequent complication that limits the surgeon's field of view and affects the operative technique. Additionally, the duration of surgery can be greatly increased as a result of such complication (De Castro et al., 2013).

Many pharmacological agents have been used for controlled hypotension among those agents are inhalational anesthetics, sodium nitroprusside, nitroglycerine, hydralazine, adenosine, beta blockers (especially esmolol), calcium channel blockers, and narcotics (Yosry & Othman, 2008). An ideal hypotensive agent can achieve the desired level of controlled hypotension with rapid onset, rapid offset, without affecting vital organ perfusion and without toxic metabolites (Standing et al., 2010).

Dexmedetomidine is a highly selective $\alpha 2$ adrenergic receptor agonist (selectivity ratio for $\alpha 2$:$\alpha 1$ is 1600:1) (Carollo et al., 2008) which causes reduction of heart rate and blood pressure beside its anxiolytic, analgesic, amnestic, and sedative properties without respiratory depression (Gupta et al., 2011). Remifentanil is an ultra short-acting opioid that can allow good control of blood pressure and minimizes blood pressure surges due to surgical stimulation without prolonged effects (Degoute et al., 2001).

The aim of the current study is to compare the efficacy of dexmedetomidine vs remifentanil infusion for controlled hypotensive anesthesia for shoulder arthroscopy as regard hemodynamic parameters, surgical field quality, and postoperative recovery profile.

Patients and methods

After obtaining ethical committee approval and patients' written informed consents, the current prospective, randomized, double-blind study was conducted on 40 adult patients undergoing shoulder arthroscopy for rotator cuff repair under general anesthesia with hypotensive technique in Ain Shams University Hospitals through the period from June 2019 to December 2019.

Inclusion criteria included patients aged between 21 to 60 years with the American Society of Anesthesiologist (ASA) physical status I or II while exclusion criteria included patients who refused to participate in this study, pregnancy, history of orthostatic hypotension, those with preexisting cerebral pathology (such as previous episodes of cerebral ischemia or stroke), carotid artery and spinal canal stenosis, uncontrolled systemic illness (e.g., hypertension, diabetes mellitus) and significant organ dysfunction (cardiac, pulmonary, renal, hepatic), and bleeding disorders. Patients with known hypersensitivity to the study drugs or running regularly on B blockers, calcium channel blockers, $\alpha 2$ adrenergic agonist, and opioids were also excluded.

Following written informed consent, patients were randomized into one of two equal groups (20 patients in each group): group D (dexmedetomidine group) and group R (remifentanil group) using closed envelop method.

Anesthesia technique

General preoperative fasting guidelines were followed. All patients received Ringer's solution at 5 ml/kg through a 20 gage intravenous cannula before entering to the operating room (OR). On arrival to the OR, standard monitoring, including, electrocardiography (ECG), noninvasive blood pressure (NIBP), and pulse oximetry were applied and baseline MAP, HR, and peripheral oxygen saturation (SpO_2) were recorded. The bispectral index (BIS) monitor electrodes were placed on the skin of the forehead after cleaning it with alcohol and were connected to BIS VISTA™ Monitoring System (Aspect Medical System, MA, USA). Intravenous midazolam 0.02 mg/kg and granisetron 10 μg/kg IV (Granitryl 1 mg/ml; Alex Co., for Egy-pharma, Egypt) were given slowly 10 min before anesthesia induction and another 20 gage intravenous cannula was applied for administration of the study drugs in both groups.

The syringes of the given study drugs (bolus and infusion) were prepared by an anesthesiologist who was not in charge of the case while the observing anesthesiologist was blinded to the infused drug. The bolus doses of the study drugs remifentanil (Ultiva; GlaxoSmithKline Manufacturing, Parma, Italy) (1 μg/kg), dexmedetomidine hydrochloride (Precedex 200 μg/2 ml, Hospira, Inc., Rocky Mount, IL, USA) (1 μg/kg) were calculated according to the patient's body weight and diluted in a normal saline solution (NSS) 0.9%. Group D had dexmedetomidine 0.9 μg/kg diluted in 50 ml filled syringe labeled "first bolus," and 0.1 μg/kg diluted in 10 ml filled syringe labeled "second bolus" while group R had the same amount of plain NSS in 50 ml filled syringe labeled "first bolus" and remifentanil 1 μg/kg diluted in 10 ml filled syringe labeled "second bolus." The infusion doses of the study drugs were prepared in 50 ml syringes labeled "infusion drug" and diluted in a normal saline solution NSS 0.9% so that dexmedetomidine concentration

(10 μg/ml) and remifentanil concentration (50 μg/ml) were achieved.

Before induction of anesthesia, the study drugs in the "first bolus" and "second bolus" labeled syringes were injected over 9 min and 1 min, respectively followed by continuous infusion of the study drugs in "infusion drug" labeled syringes at 0.03-0.06 mL/kg/h using an infusion pump (B-Braun, Bethlehem, USA). The aim of this infusion regimen was to give a loading dose of dexmedetomidine 1 μg/kg over 10 min followed by a continuous infusion of 0.3-0.6 μg/kg/h and remifentanil 1 μg/kg over 1 min followed by a continuous infusion of 0.25-0.5 μg/kg/min.

All patients were pre-oxygenated with 100% oxygen for 3 min and anesthesia was induced with intravenous 1 μg/kg fentanyl (Sunny Pharmaceutical, Egypt under license of Hamelin Pharmaceuticals, Germany) followed by intravenous propofol (Propofol 1%; Fresenius Kabi Deutschland GmbH Grazia) 10 mg increments every 5 s until the BIS reached a value of 60. After loss of consciousness, intravenous atracurium (Tracrium; GlaxoSmithKline Manufacturing) 0.5 mg/kg was administered and the patients were intubated 2-3 min later with cuffed endotracheal tubes then mechanically ventilated targeting end-tidal CO_2 of 30–35 mmHg. Anesthesia was maintained with sevoflurane (Sevorane; Abbott Laboratories, Illinois, USA) which was started at 2% and titrated aiming BIS in the target range of 40-60 and muscle relaxation was provided with atracurium top-up doses (0.1 mg/kg) as needed.

Invasive arterial blood pressure monitoring was done by using a 20 gage catheter inserted into a radial artery in the contralateral side of the operation which was connected to a pressure transducer with a reference point of the mid-axillary line in the supine position; then all patients were changed gradually into the beach chair position and the head was secured in a neutral position to ensure adequate cerebral venous drainage. The back of the operating room table was then raised to 65-75° above the horizontal plane with readjustment of the pressure transducer position to a new reference point of external ear canal level to reflect the cerebral perfusion pressure then surgery was started. Ringer's solution was administered continuously at a rate of 5 ml/kg/h during surgery while normal saline was used as irrigation fluid for surgery. The irrigation fluid pump pressure and flow rate were in the normal recommended range of 40–80 mmHg and 50–150 mL/min (Gupta et al., 2016). In order to exclude interpersonal variation in evaluation of the surgical field, a single surgeon was responsible for doing all the procedures, who was blinded to the study medication used.

The infusion rate of remifentanil and dexmedetomidine were titrated to maintain MAP of 60–70 mmHg. Signs of insufficient analgesia defined as increase in HR and MAP exceeding 20% of baseline values while BIS was within the targeted range (40-60) were managed by increasing the infusion rate of the studied drug by 20% increments per minute till the maximum infusion rate of the drug in the study protocol if required and if persisted additional boluses of fentanyl 0.5 μg/kg was given. If BIS was within the target range and hypotension (MAP below 60 mmHg) occurred, the infusion rate of the study drug was reduced by 20% increments per minute till the minimum infusion rate of the drug in the study protocol, the rate of intravenous fluids was increased and IV 5 mg ephedrine boluses was administered. If no increase in MAP could be obtained, the infusion of the study drug was discontinued, and the patient was excluded from the study. Bradycardia (defined as HR below 50 beat/minute), was managed by 0.5 mg atropine intravenous. If no increase in HR could be obtained, the infusion of the study drug was discontinued, and the patient was excluded from the study.

All the study infused drugs were discontinued 10 min before the end of operation, and paracetamol (perfalgan, Bristol-Myers Squibb Pharmaceutical Limited NY, USA) 1 g was given by intravenous infusion. Sevoflurane was discontinued when last surgical stitch was placed and the patients were repositioned to a supine position and after gentle oral suction, extubation was done when full reversal of muscle relaxation (using 0.02 mg/kg of neostigmine with atropine 0.01 mg/kg) and BIS value reached 80 then the patients were transferred to the postanesthesia care unit [PACU]. Upon arrival to the PACU, SpO_2, MAP, and HR were recorded. Postoperative recovery was assessed by the modified Aldrete score (Aldrete, 1995). Postoperative Ramsay sedation score (Table 1) (Ramsay et al., 1974) was used for assessment of sedation and visual analog scale (VAS) (Breivik et al., 2008) for postoperative pain assessment. This scale ranges from 0 to 10 cm where 0 represents no pain and 10 represents worst pain. If the patient requested analgesics due to pain or the VAS score was ≥ 4, the patients received non-steroidal anti-inflammatory drugs (ketorolac 30 mg) diluted to 10 ml slowly intravenous, after 30 min if the VAS score was still higher than 4, intravenous

Table 1 Ramsay sedation score (Ramsay et al., 1974)

1. Patient is anxious, agitated, or restless.
2. Patient co-operative, oriented, and calm.
3. Patient is responsive to verbal command.
4. Patient exhibiting brisk response to light glabellar tap or to an auditory stimulus.
5. Patient exhibiting a sluggish response to light glabellar tap or to an auditory stimulus.
6. No response to any of these stimulations

fentanyl 20 μg was given which could be repeated after 15 min if postoperative pain persisted until VAS was less than 4 then patients were discharged from PACU after 2 h observation period.

Demographic data including age and gender were collected. The procedure-related variables including surgical and anesthesia duration were also recorded. The primary outcome of the current study was the assessment of hemodynamic parameters including (MAP, HR) in both groups which were recorded at arrival to the operating room (T_0), after anesthesia induction (T_1), after intubation (T_2), at 20 min intervals from induction time during the remaining of the procedure ($T_{3,4,5,6,7}$), 5 min after stopping studied drug infusion (T_8) after extubation (T_9), then after 30 min,1 h, and 2 h of arriving to PACU (T_{10}, T_{11}, T_{12}). The secondary measures included surgical field evaluation and surgeon satisfaction with the quality surgical field using shoulder arthroscopy grading scale (Table 2) (Lands et al., 2019) then a simple questionnaire for the surgeon satisfaction with the quality of the surgical field was done (1 = satisfactory, 0 = unsatisfactory).

The time between discontinuation of the inhaled anesthetic and tracheal extubation (defined as extubation time) as well as the time needed to reach modified Aldrete score ≥ 9 after PACU arrival (defined as anesthesia recovery time) were recorded. Postoperative Ramsay sedation score was recorded on arrival to PACU then 15, 30, 60, 120 min later, and VAS score was also recorded at the same intervals and the time to first postoperative analgesic in both groups. The incidence of perioperative adverse events like hypotension, bradycardia, nausea/vomiting, and shivering which were recorded intraoperative and during PACU stay.

Statistical analysis

Using G power program, setting alpha error at 5% and power at 80%. Results from previous study (Abdel-Hamid, 2017) showed that MAP in dexmedetomidine group intraoperatively was 73.8 ± 9.04 compared to 84.06 ± 8.9 for fentanyl group. Based on this, the needed sample is 20 cases per group with 20% dropout rate taken into consideration. Patients data were collected, tabulated, and then analyzed using the SPSS version 16.0 computer software (Chicago, IL, USA). Numerical variables were presented as mean ± standard deviation or median (min-max), while categorical variables were presented as number of cases (percentage). A comparison of numerical variables between the two study groups was performed with an unpaired Student's t test, and within the same group was performed using paired Student's t test while the comparison of categorical variables between the two study groups was performed by chi-square or Fisher's exact test as appropriate. Ramsay sedation scores were compared using Mann–Whitney U test. P values less than 0.05 were considered statistically significant.

Table 2 Shoulder arthroscopy grading scale (Lands et al., 2019)

Grade 1. Excellent—adequate visualization of anatomic structures with minimal need for additional intervention such as electrocautery or temporary altering pump pressure
Grade 2. Good—adequate visualization of anatomic structures with occasional need for electrocautery or temporary altering pump pressure
Grade 3. Average—visualization of anatomic structures requires frequent use of both electrocautery and altering pump pressure
Grade 4. Poor—inadequate visualization of anatomic structures despite using both electrocautery and altering pump pressure

Results

A total of 55 patients were assessed for eligibility in the current study of which fifteen patients were excluded (three patients declined to participate and twelve patients did not meet the inclusion criteria). The remaining 40 patients (20 patients in each group) were followed up all the study procedure and included in the final data analysis (Fig. 1).

Demographic data

There were no statistically significant differences between the two study groups as regards the demographic data and ASA status ($P > 0.05$) (Table 3).

Procedure-related variables

There was no statistically significant difference between the two study groups as regards the surgical and anesthesia duration ($P > 0.05$) (Table 4).

Hemodynamic measurements

Regarding MAP changes in the study groups

As regards the MAP changes, there was no significant difference between both groups at all perioperative recordings ($P > 0.05$). The MAP values after anesthesia induction (T_1) and at (T_3-T_8) recordings were significant lower than baseline values (T_0) in both groups ($P < 0.05$) with no significant difference of MAP recordings after intubation (T_2), after extubation (T_9), at PACU recordings (T_{10}-T_{12}) when compared with T_0 in both groups ($P > 0.05$) (Table 5).

Regarding HR changes in the study groups

As regards the HR changes, there was no significant difference between both groups at (T_0-T_8) recordings and at T_{12} ($P > 0.05$), but the HR was significantly lower in group D when compared with group R at (T_9-T_{11}) recordings ($P < 0.05$) (Table 6).

In group R, the HR recordings after anesthesia induction (T_1) and at (T_3-T_8) recordings were significantly lower than baseline values (T_0) ($P < 0.05$) with no significant difference of HR recordings after intubation (T_2),

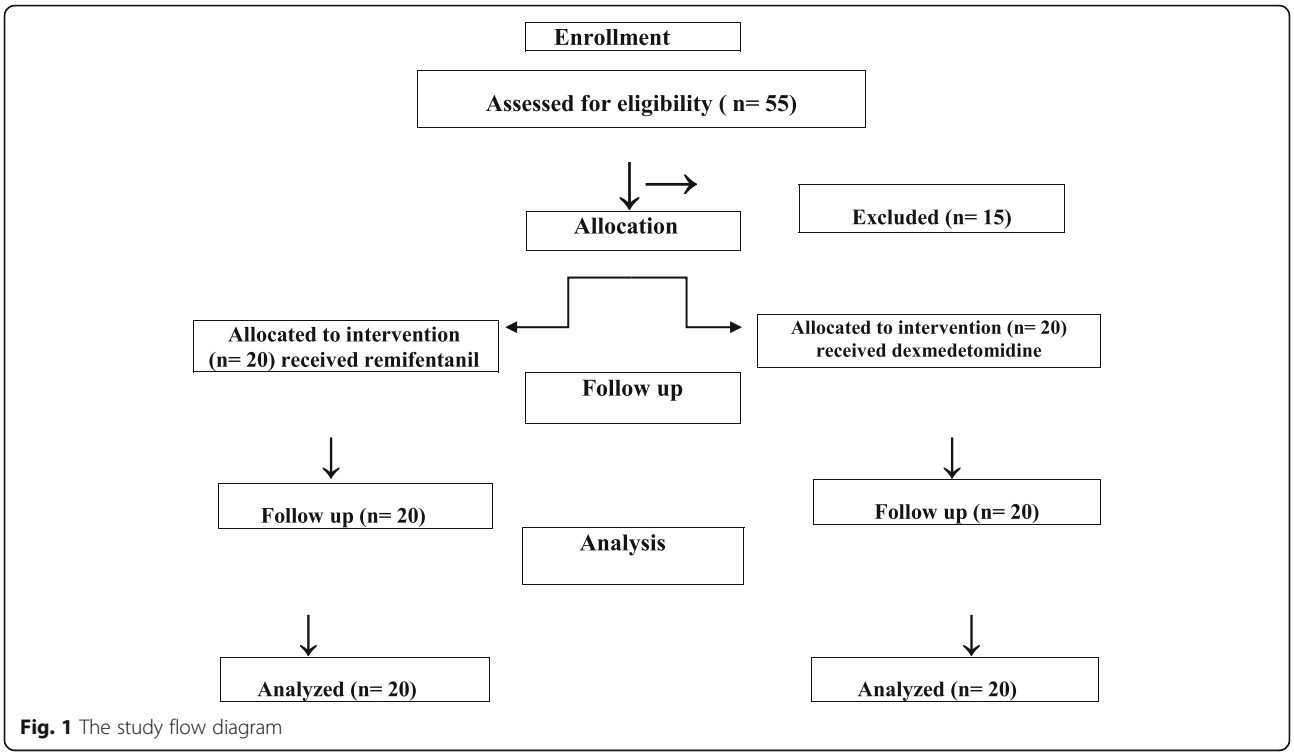

Fig. 1 The study flow diagram

after extubation (T_9),at PACU recordings (T_{10}-T_{12}) when compared with T_0 ($P > 0.05$). In group D, the HR recordings after anesthesia induction (T_1) and at (T_3-T_{11}) recordings were significant lower than baseline values (T_0) ($P < 0.05$) with no significant difference of HR recordings after intubation (T_2) and after 2 h PACU stay (T_{12}) when compared with T_0 ($P > 0.05$) (Table 6).

Surgical field evaluation and surgeon satisfaction

Both surgical field assessment using shoulder arthroscopy grading scale and surgeon satisfaction with the field visibility during surgery showed no significant difference between both study groups ($P > 0.05$) (Table 7).

Anesthesia recovery time

The extubation time and anesthesia recovery time were significantly longer in group D when compared with group R ($P < 0.05$) (Table 8)

Table 3 Demographic patients' characteristics and ASA status (data are presented as mean ± SD)

	Group R (n = 20)	Group D (n = 20)	P value
Age (years)	42.73 ± 9.62	40.66 ± 8.14	0.467
Sex (M/F)	12/8	11/9	0.749
Weight (kg)	81.53 ± 8.24	83.94 ± 11.56	0.452
ASA			
I	8	10	0.525
II	12	10	

Postoperative Ramsay sedation score recordings

The Ramsay sedation score recorded upon arrival to PACU, 15, 30 minutes and 1 h later were significantly higher in the group D when compared with that of the group R ($p < 0.05$) with no intergroup significant difference at 2 h recordings ($P > 0.05$) (Table 9).

Postoperative analgesia

Postoperative VAS scores recordings

The VAS recorded upon arrival to PACU, 15, 30 min,1 h, and 2 h later were significantly higher in the group D, compared with that of the group R ($P < 0.05$) (Table 10).

The time to 1st postoperative analgesic requirement

The time to 1st postoperative analgesic requirement was significantly longer in group D when compared with group R ($P < 0.05$) (Table 11).

The postoperative analgesic requirements

The number of patients required ketorolac and fentanyl as rescue analgesic during their PACU stay was

Table 4 Procedure-related variables in both groups (data are presented as mean ± SD)

	Group R (n = 20)	Group D (n = 20)	P value
Anesthesia time (min)	157.43 ± 19.32	163.67 ± 24.12	0.372
Surgery time (min)	139.77 ± 18.93	147.84 ± 21.57	0.216

Table 5 Mean arterial blood pressure (mmHg) changes in the study groups (data are presented as mean ± SD)

	Group R (n = 20)	Group D (n = 20)	P value
T_0	84.75 ± 9.44	86.23 ± 10.86	0.648
T_1	75.46 ± 8.62*	78.53 ± 9.44*	0.289
T_2	85. 83 ± 10.72	86.27 ± 9.88	0.893
T_3	65.64 ± 4.26*	67.11 ± 3.12*	0.220
T_4	64.92 ± 4.42*	66.23 ± 3.28*	0.293
T_5	65.33 ± 3.77*	64.28 ± 4.14*	0.407
T_6	64.55 ± 4.28*	63.76 ± 3.08*	0.420
T_7	64.28 ± 3.79*	65.48 ± 4.33*	0.356
T_8	68.37 ± 5.56*	69.83 ± 6.86*	0.464
T_9	79.75 ± 10.69	83.16 ± 8.74	0.276
T_{10}	83.54 ± 8.74	85.34 ± 7.25	0.482
T_{11}	89.77 ± 8.33	87.45 ± 7.94	0.373
T_{12}	90.14 ± 9.89	86.12 ± 8.44	0.174

*Statistically significant (P value < 0.05) (when compared with baseline value)

significantly lower in Group D when compared with group R ($P < 0.05$) (Table 12).

Perioperative adverse events in the studied groups

Bradycardia was observed in 5 patients (2 patients in group R and 3 patients in group D) with no intergroup statistical significant difference ($P > 0.05$). In all cases of bradycardia, atropine (0.5 mg IV bolus) was sufficient only once and no need for a repeat to restore the HR. Hypotension was observed in 4 patients (2 patients in each group) with no intergroup statistical significant difference ($P > 0.05$). Hypotension promptly responded to adjustment of the rate of studied drug infusion and increasing the rate of intravenous fluids but intravenous ephedrine 5 mg boluses were required in 2 patients of them (1 patient in each group). Nausea/vomiting occurred in 4 patients in group R (20%) and 2 patient in group D (10 %) which was treated by intravenous ondansetron 4 mg while shivering occurred in 3 patients in group R (20%) and 1 patient in group D which responded to a small dose of intravenous pethidine (25 mg) with no intergroup statistical significant difference ($P > 0.05$) (Table 13).

Table 6 Heart rate (beat/min) changes in the study groups (data are presented as mean ± SD)

	Group R (n = 20)	Group D (n = 20)	P value
T_0	82.87 ± 10.67	84.23 ± 9.45	0.672
T_1	73.53 ± 7.44*	71.46 ± 8.45*	0.446
T_2	80.47 ± 9.26	81.25 ± 7.72	0.635
T_3	71.85 ± 7.68*	72.83 ± 6.63*	0.668
T_4	67. 93 ± 6.87*	66.74 ± 5.54*	0.550
T_5	63. 24 ± 7.12*	64.59 ± 6.21*	0.526
T_6	65.49 ± 6.94*	66.47 ± 7.35*	0.667
T_7	66.26 ± 7.63*	64.35 ± 8.76*	0.466
T_8	70.23 ± 8.76*	66.75 ± 7.44*	0.187
T_9	79.85 ± 6.47	72.46 ± 7.68*,†	$P < 0.05$
T_{10}	82.23 ± 7.56	75.63 ± 8.73*,†	$P < 0.05$
T_{11}	86.77 ± 8.66	78.64 ± 7.45*,†	$P < 0.05$
T_{12}	84.54 ± 7.85	81.55 ± 7.69	0.231

*Statistically significant (P value < 0.05) (when compared with baseline value)
†Statistically significant (P value < 0.05) (group D versus group R)

Discussion

Many methods have been used to optimize the surgical conditions in certain surgical procedures; due to the lack of ability to use of tourniquet, the beach chair positions (BCP) together with deliberate hypotension were used to decrease intraoperative blood loss during arthroscopic shoulder surgeries (Duralde, 2009). The current study was conducted to compare the efficacy of intraoperative intravenous infusion of dexmedetomidine versus remifentanil for induced controlled hypotensive anesthesia in patients undergoing elective arthroscopic shoulder surgery in the BCP.

Most of the studies for controlled intraoperative hypotension intended to keep the MAP between 50-60 mmHg (Degoute, 2007). Erdem et al. (2016) assessed the effect of controlled hypotension using remifentanil infusion on regional cerebral oxygen saturation ($rScO_2$) by near-infrared spectroscopy (NIRS) in patients undergoing rhinoplasty. In their study, they reported that the decrease of MAP to 50-60 mmHg caused cerebral desaturation in 10% of the patients. Another study by Maghawry et al. (2015) assessed the effect of controlled hypotension using dexmedetomidine vs esmolol on cerebral oxygen saturation in 50 patients undergoing shoulder arthroscopy. In their study, they reported that the decrease of MAP to 55-65 mmHg caused cerebral desaturation in 2 patients (8%) in dexmedetomidine group and 5 patients (20%) in esmolol group.

Based on these results (Erdem et al., 2016; Maghawry et al., 2015), in the current study, we targeted MAP was 60-70 mmHg during the procedure to minimize the chance for occurrence of cerebral hypoxia. The controlled hypotension was achieved intraoperatively in both groups with no intergroup significant difference. The MAP values after anesthesia induction and during the induced hypotension (T_3-T_7 recordings) were significant lower than those at baseline in both groups. The hemodynamic responses (MAP and HR) to both intubation and extubation were successfully attenuated in both groups and the surgical field condition was satisfactory on surgeon assessment in both groups.

Table 7 Operative field data and surgeon satisfaction (data are presented as number (%))

Shoulder arthroscopy grading scale	Group R (n = 20)	Group D (n = 20)	P value
Grade 1	14 (70%)	12 (60%)	0.507
Grade 2	6 (30%)	8 (40%)	
Grade 3	0 (0)	0 (0)	
Grade 4	0 (0)	0 (0)	
Surgeon satisfaction			
Satisfied	20 (100%)	20 (100%)	1
Not satisfied	0 (0)	0 (0)	

These findings were consistent with those reported by Özcan et al. (2012) who assessed the effect of dexmedetomidine versus remifentanil for controlled hypotensive anesthesia in functional endoscopic sinus surgery (FESS). In their study, both dexmedetomidine and remifentanil provided adequate controlled hypotensive anesthesia and favorable surgical field condition with no significant difference between both groups as regards the MAP and HR recordings except for the significantly lower HR recorded after extubation and in PACU recordings in dexmedetomidine group when compared with remifentanil group which was also observed in our current study. A similar efficacy of both remifentanil and dexmedetomidine on the intraoperative hemodynamics and surgical field condition was also reported by Lee et al. (2013), Kim et al. (2015b) in FESS and Javaherforooshzadeh et al. (2018) in lumbar discectomy surgeries.

The reduction of both HR and MAP with dexmedetomidine is due to its stimulation of presynaptic $\alpha 2$ receptors with inhibition of noradrenaline release from the peripheral nerve terminal (Morgan et al., 2006) and its inhibitory effect on central sympathetic outflow caused by stimulation of the $\alpha 2$ receptor in locus ceruleus of brainstem (Farag et al., 2012). The effect of remifentanil, an ultra short-acting opioid on hemodynamics is typical of opioids (decreased MAP and HR). The reduced blood pressure is by virtue of the bradycardia caused by a centrally mediated increase in vagal nerve activity (Lee et al., 2018), and the direct effects of remifentanil on regional vascular tone which may play a role in promoting hypotension (Noseir et al., 2003; Jones, 2003).

In the current study, the time to extubation and anesthesia recovery time were significantly longer with group D when compared with group R. The same findings were supported by multiple previous studies (Özcan et al., 2012; Javaherforooshzadeh et al., 2018; Bulow et al., 2007; Turgut et al., 2009; Karabayirli et al., 2017; Modir et al., 2018). The more extended sedation observed with dexmedetomidine, when compared to that of remifentanil is attributed to shorter elimination half-life of remifentanil (9-10 min) (Videira & Cruz, 2004a) vs (2.1-3.1 h) for dexmedetomidine (Weerink et al., 2017) which was also responsible for the significantly higher Ramsay sedation scores recorded upon arrival to PACU 15, 30 min, and 1 h later in group D when compared with group R. One of the main advantages of dexmedetomidine that it has no effect on the ventilatory response to blood carbon dioxide (Hsu et al., 2004) with lack of any associated respiratory depression (Na et al., 2011; Buck, 2010).

Table 8 Anesthesia emergence times (data are presented as mean ± SD)

Time recorded	Group R (n = 20)	Group D (n = 20)	P value
Extubation time (min)	7.81 ± 1.94	11.12 ± 2.75†	$P < 0.05$
Anesthesia recovery time (min)	15.44 ± 2.94	23.43 ± 4.55†	$P < 0.05$

†Statistically significant ($P < 0.05$) (group D versus group R)

Table 9 Ramsay sedation score recordings (data are presented as median (min-max))

	Group R (n = 20)	Group D (n = 20)	P value
Upon arrival to PACU	3.5 (3-4)	4.5 (4-5)†	$P < 0.05$
After 15 (min)	3 (2-4)	4 (3-5)†	$P < 0.05$
After 30 (min)	2 (2-3)	3 (3-4)†	$P < 0.05$
After 1 (h)	2 (1-3)	3 (2-4)†	$P < 0.05$
After 2 (h)	2 (1-3)	2 (2-3)	0.118

†Statistically significant (P value < 0.05) (group D versus group R)

Regarding postoperative analgesia in the current study, there was a statistically significant lower postoperative VAS score recordings in group D when compared with group R. The time to 1st postoperative analgesic requirement was significantly longer and the postoperative analgesic requirement during PACU stay was significantly lower in group D when compared with group R. The perioperative analgesic activity and analgesic sparing effect of $\alpha 2$ agonists have been proved in multiple studies (Arain & Ebert, 2002; Gurbet et al., 2006; Durmus et al., 2007; Ngwenyama et al., 2008; Tufanogullari et al., 2008; Gupta et al., 2013; Alzeftawy & Elsheikh, 2015; Rayan, 2016) which seems to be mediated by both supraspinal and spinal mechanisms. It is thought that central $\alpha 2$ adrenoceptors in the locus ceruleus and in the dorsal

Table 10 VAS score recordings in both groups (data are presented as mean ± SD)

	Group R (n = 20)	Group D (n = 20)	P value
Upon arrival to PACU	2.83 ± 0.65	1.84 ± 0.75†	$P < 0.05$
After 15 (min)	3.44 ± 1.17	2.35 ± 0.61†	$P < 0.05$
After 30 (min)	4.35 ± 0.94	3.14 ± 0.87†	$P < 0.05$
After 60 (min)	4.63 ± 1.32	3.88 ± 0.92†	$P < 0.05$
After 120 (min)	4.77 ± 1.27	3.55 ± 1.14	$P < 0.05$

†Statistically significant (P value < 0.05) (group D versus group R)

Table 13 Perioperative adverse events in both study groups (data are presented as number (%))

Side effects	Group R (n = 20)	Group D (n = 20)	P value
Bradycardia	2 (10%)	3 (15%)	0.632
Hypotension	2 (10%)	2 (10%)	1
Nausea/vomiting	4 (20%)	2 (10%)	0.375
Shivering	3 (15%)	1 (5%)	0.184

horn of the spinal cord are involved in this activity (Guo et al., 1996; De Kock et al., 1993). When comparing remifentanil to other short-acting opioids (fentanyl, alfentanil, and sufentanil), it is associated with deeper anesthesia and analgesia intraoperatively (Komatsu et al., 2007). However,the most encountered problems with remifentanil infusion is the acute tolerance to its analgesic effect (Vinik & Kissin, 1998), the fast offset of its analgesia owing to its short elimination half-life which requires adding other analgesics before infusion stoppage (Videira & Cruz, 2004b) and postoperative rebound hyperalgesia with associated increase in postoperative opioid consumption (Fletcher & Martinez, 2014) which could explain the significantly higher VAS score encountered in group R when compared with group D. These results of the current study run in accordance with a recent meta-analysis by Grape et al. (Grape et al., 2019) who assessed the effect of intraoperative infusion of dexmedetomidine vs remifentanil on postoperative analgesic requirement in twenty-one randomized clinical trials and they reported that time to analgesia request was significantly longer, and use of postoperative morphine and rescue analgesia was significantly lower with dexmedetomidine when compared with remifentanil. Similarly, higher postoperative pain scores were reported in cases of remifentanil use in the maintenance of anesthesia in children undergoing adenotonsillectomy when compared with N_20 or fentanyl (Choi et al., 2011; Davis et al., 2000).

In the current study, nausea and vomiting was the most common side effect in group R (20%) which was treated by intravenous ondansetron while bradycardia was the most frequent adverse effect in group D (15%) which responded to intravenous atropine injection, but there was no significant difference between the study groups regarding the incidence of side effects.

Table 12 Postoperative analgesic requirements (data are presented as number (%))

	Group R (n = 20)	Group D (n = 20)	P value
Postoperative ketorolac requirements, no. of patients	18	9	$p < 0.05$
Postoperative fentanyl requirements (1st bolus), no. of patients	12	4	$p < 0.05$
Postoperative fentanyl requirements (2nd bolus), no. of patients	7	1	$p < 0.05$

Table 11 The time to 1st postoperative analgesic (mean ± SD)

Time recorded	Group R (n = 20)	Group D (n = 20)	P value
The time to 1st postoperative analgesic (min)	20.85 ± 11.32	51.38 ± 19.77[†]	$P < 0.05$

[†]Statistically significant (P value < 0.05) (group D versus group R)

Study limitations

The current study had several limitations. First, the small sample size may not have enabled the detection of adverse events that could occur with a low frequency. Second, also, we did not include critically ill patients, and the patients were ASA I and II only, thus may limit the application of the findings on clinically unstable patients with comorbidities. Third, further studies are needed to assess postoperative analgesia for a longer duration (24-48 h). Fourth, it was better to monitor $rScO_2$ using NIRS to avoid cerebral desaturation events but this monitor is unavailable in our hospital. Lastly, the cost implications for the studied drugs should be considered.

Conclusion

In conclusion, both remifentanil and dexmedetomidine can induce adequate levels of hypotensive anesthesia and satisfactory surgical field visibility in patients undergoing shoulder arthroscopy under general anesthesia. Patients treated with dexmedetomidine had better quality and more extended postoperative analgesia but longer postoperative anesthesia recovery and higher postoperative sedation scores when compared with remifentanil.

Abbreviations

ASA: American Society of Anesthesiologist; BIS: Bispectral index; ECG: Electrocardiography; FESS: Functional endoscopic sinus surgery; MAP: Mean arterial pressure; NIRS: Near-infrared spectroscopy; NSS: Normal saline solution; OR: Operating room; PACU: Post anesthesia care unit; $rScO_2$: Regional cerebral tissue oxygen saturation; VAS: Visual analog scale

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Authors' contributions

MAM who contributed to study conception and design, acquisition of data, analysis and interpretation of data. HMF: drafting of the manuscript and its critical revision. All authors have read and approved the final version of the manuscript.

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Availability of data and materials

The datasets generated during and/or analyzed during the current study are not publicly available due to restrictions based on privacy regulations and informed consent of the participants, but are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The current prospective randomized double-blinded study was conducted on 40 adult patients scheduled to undergo shoulder arthroscopy in Ain

Shams university hospital through the period from June 2019 to December 2019 after obtaining approval of research ethical committee (REC) of Faculty of medicine - Ain Shams University (FMASU) at March 2019 with a reference number of FMASU R 22/2019 and patients' written informed consents for acceptance of participation in the study.

Consent for publication
Not applicable

Competing interests
The authors declare that they have no competing interests.

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