Pakistan Veterinary Journal

ISSN: 0253-8318 (PRINT), 2074-7764 (ONLINE)
Accessible at: www.pvj.com.pk

RESEARCH ARTICLE

Comparison of Blind, Ultrasound and Computed Tomographic-Guided Injection Techniques for Nerve Block of the Head in One-Humped Camel (*Camelus dromedaries*) Cadavers

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ARTICLE HISTORY (16-177)

Received:	July 13, 2016
Revised:	December 23, 2016
Accepted:	December 28, 2016
Published online:	January 16, 2017

Key words:
Camel
Computed tomography
Imaging
Nerve block
Ultrasonography

A B S T R A C T

The present study was designed to assess the efficacy of ultrasound (US) and computed tomographic (CT)-guided injection techniques versus conventional blind technique for various nerve blocks of the head in one-humped camel cadavers. Eighteen cadaver heads of adult one-humped camels enrolled were randomly assigned to blind (n=6), US-guided (n=6), and CT-guided (n=6) injections of mental, infraorbital, supraorbital and retrobulbar nerves. Injections were made with 2.5 mL of lidocaine HCl mixed with equal volume of Iopaminol contrast agent. Injection criteria (needle localization, correct penetration, difficulty of injection and performance time) were assessed, scored and statistically compared among three techniques of injection. Collectively, the summation of injection criteria scores showed a significant increase (P<0.05) in the US and CT-guided nerve block injection techniques compared with the blind technique. Imaging-guided injection could precisely discriminate each target nerve (sensitivity: 72.2-94.4%; specificity: 27.8-83.3%; odds ratio: 6.5-85; CI: 15.03-389; P<0.0001). The highest specificity for imaging-guided nerve block injection technique was 83.3% for US and CT-guided techniques, whilst the lowest specificity was recorded for CT versus US-guided technique (27.8%). In conclusion, the US and CT-guided injection techniques offers considerable advantages for characterization of the anatomical landmarks, needle placement and selectivity of the head nerve block technique which is difficult to obtained using conventional blind technique.

To Cite This Article: El-Shafaey ES, Hamed M, Abdellatif A and Elfadl EA, 2017. Comparison of blind, ultrasound and computed tomographic-guided injection techniques for nerve block of the head in one-humped camel (*Camelus dromedaries*) cadavers. Pak Vet J, 37(2): 180-184.

INTRODUCTION

Dromedary camels (*Camelus dromedaries*), are large even-toed ungulate single-humped camels that are important livestock species for people in harsh and tropical environments (Fowler, 1997). The importance of camel is conferred by the production of meat, milk, leather and wool, and through their use in riding tourism and sports and as eco-friendly economic means of pack and transportation (Abdul Rahim *et al.*, 1994). The camel's head is the home of body's major vital organs which has a significant clinical importance in veterinary practice (Dyce *et al.*, 2002; Monfared, 2013). Nerve block of the head is a very useful tool that facilitates treating facial trauma and dental extraction in camels (Huichu and Walz, 2014). Despite the dromedary camel's popularity, information regarding various imaging-guided nerve block techniques for the head in this species is limited (Osuobeni and Hamidzada, 1999).

In camels, general anesthesia represents a great challenge for surgeon due to great liability for asphyxia and drenching pneumonia rather than its costs and special equipments required in comparison with regional anesthesia (Hall *et al.*, 2000). Conventional blind nerve block has been considered the gold standard technique for nerve infiltration in regional anesthesia practice (Huichu and Walz, 2014). It represents a challenge for veterinary anesthetist which often requires multiple trial-and-error needle attempts, resulting in procedure time, procedure-related pain, poor in efficiency and complications including hemorrhage, nerve injuries and miss injection (Marhofer and Chan 2007; Rioja *et al.,* 2012). Visualization of both needle passage and local anesthetic spread may improve the safety and quality of these techniques in the practice of veterinary anesthesia for surgical procedures especially of the head in camels (Osuobeni and Hamidzada, 1999; Chapman *et al.,* 2006).

Accurate and efficient identification of nerves is critically important in interventional pain management procedures such as nerve blocks (Helen *et al.,* 2015). Several methods have been implemented in clinical practice to facilitate nerve identification. Among various imaging guidance modalities, ultrasound (US) and computed tomography (CT)-guided nerve block were widely used for facilitating nerve blocks (Calvillo *et al.,* 2000; Campoy *et al.,* 2010; Echeverry *et al.,* 2012), however, the application of these techniques in veterinary practice is still limited. Therefore, the present study was designed to assess the efficacy of US and CT-guided injection techniques versus blind technique for head nerves in one-humped camels, based on discrimination of the injection criteria.

MATERIALS AND METHODS

Cadavers: A total of 18 heads of adult one-humped camel cadavers (Mean±SD age at slaughter: 60±12 months) weighting between 400-550 kg (475±75 kg), recently slaughtered at the local abattoir of Dakahlia Governorate (Egypt) for conditions unrelated to the head, were randomly selected for this study.

Study design: Cadaver heads enrolled were randomly assigned to blind (n=6), US-guided (n=6), or CT-guided (n=6) injection of mental, infraorbital, supraorbital and retrobulbar nerves. Injections were made with 2.5mL of lidocaine HCl (Debocaine 2%, Al-Debeiky Pharmaceutical Industrial Co, Egypt) mixed with equal volume of Iopaminol contrast agent (Scanlux®300, Sanochemia Pharmazeutika AG-Germania). The study protocol was approved by the committee of animal welfare and ethics, Faculty of Veterinary Medicine, Mansoura University, Egypt.

Blind technique: By palpating the anatomical landmarks of the head foramens related to the target nerve and introducing a 22-gauge spinal needle (NID, Medical Company, Egypt) in correct manner till successful injection (Fig. 1), as described by Huichu and Walz (2014).

US-guided technique: Ultrasound-guided injection was carried out using 7.0 to 10.0 MHz mechanical linear multifrequency transducer (Mindray DP-2200Vet., PR China) in transverse and longitudinal ultrasound planes. A 90-mm long 22-gauge spinal needle with stylet was introduced in plane technique using ultrasound guidance and directed with approximately 75° angle to the skin in relation to the investigated nerve site using the same landmarks as for the blind technique (Fig. 2A). The position of the needle tip in relation to the safety margin of the target nerve exit was verified on the sonogram and corrected if needed. After confirming the target nerve, to ensure needle visualization, a 2.5mL of lidocaine HCl/ Iopaminol mixed with equal volume was injected at the margin of the nerve foramen, which viewed as a hypoechoic area around the nerve. While, the retrobulbar nerve injection, was performed with the US transducer was applied on the closed upper eye lid (Fig. 2B), as described by Morath *et al.* (2013).

Fig. 1: Location of needle placement for blind injection of the mental nerve in camel head cadavers.

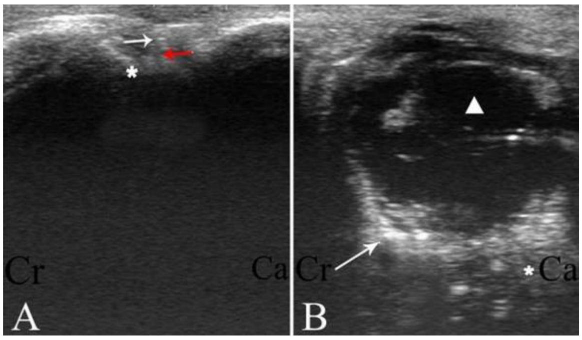

Fig. 2: A) Longitudinal ultrasonographic image of anatomical landmarks used for injection of the infraorbital nerve of camel head cadavers. The needle tip is seen as hyperechoic interface (white arrow) and positioned adjacent but not in contact with the nerve in the infraorbital foramen (read arrow). The maxilla (asterisk) casts an acoustic shadow serves as initial landmark for identification of the target nerve. B) Transverse ultrasonographic image of anatomical landmarks used for injection of the retrobulbar nerve of camel head cadavers. The needle tip at the target site for retrobulbar nerve injection is indicated by the white arrow. The center of the eye lens appears hypoechoic (arrow head), whereas the retrobulbar fat is hypoechoic with hyperechoic flecks (asterisk).

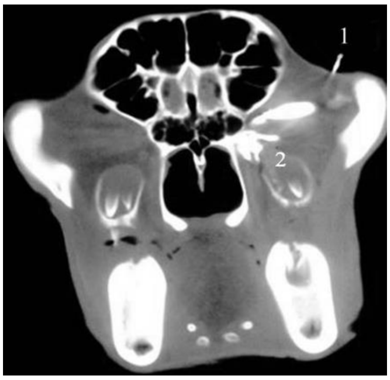

Fig. 3: Transverse CT image of the camel head at the level of bony orbit showing the needle insertion behind the eyeball (1) for retrobulbar nerve injection and the injected contrast dye has reached optic canal (2).

CT-guided technique: The CT-guided injection was performed using a multislice CT scanner (Aquilion One™ Toshiba, Toshiba America Medical Systems, USA). Transverse and sagittal CT images of each nerve block were reconstructed. The acquisition settings were 135 kV, and 250 mA with 1.0 mm slice thickness. The tomographic scan angle was 90°on the head midline nasal and frontal surfaces and 2 different image reconstructions (bone and soft tissue window). After all needles, had been advanced, 1-mm-slice axial transverse plain CT scans were obtained to trace the inserted needles. For evaluation of the initial position of the needle in relation to the nerve block, a contrast CT view was obtained. A 2.5mL of lidocaine HCl mixed with equal volume of Iopaminol was injected slowly over 5 seconds through the needles at each level of orbit and foramens. The CT scans were repeated immediately, i.e., less than 1 min after the last injection and the needle was repositioned as needed according to the CT view (Fig. 3).

Evaluation parameters: Injection criteria for efficiency of the three injection techniques were evaluated and scored by expert anatomist, sonographer and radiologist. Descriptive details of the scores and definitions of the injection criteria of the injection techniques were reported in Table 1.

Statistical analysis: Statistical analysis was performed using GraphPad Prism statistical software program (GraphPad Prism for win. version 5.0, GraphPad software Inc., USA). The injection criteria scores were compared among the three techniques of injection by the Kruskal-Wallis nonparametric ANOVA test. Data were presented as sensitivity, specificity, P value, confidence interval, odds ratio, positive predictive value and negative predictive value. Significance was considered when P<0.05.

RESULTS

The summation of injection criteria scores showed a significant increase (P<0.05) in the US and CT-guided injection techniques compared with the blind one. However, the median and range of the injection criteria scores awarded between US and CT-guided techniques was marginally less significant. The median and range for the injection criteria scores in three injection techniques are presented in Tables 2-5.

Comparison of injection criteria between the blind, US and CT-guided injection techniques showed that the performance time was significantly lower with CT-guided compared with US-guided and blind injection techniques (7 min vs 10 min and 15 min, respectively, Table 5). The needle localization and correct penetration were significantly higher in both CT and US-guided techniques in comparison to blind ones (Tables 2, 3). Regarding the difficulty of injection, it was significantly higher in blind technique compared to US and CT-guided techniques (Table 4).

Imaging-guided injection could precisely discriminate each target nerve (sensitivity 72.2-94.4%, specificity 27.8-83.3%, odds ratio 6.5-85, confidence interval 15.03-389 and P value 0.0001). The results presented in Table 6 show that, the highest specificity for nerve block injection techniques was 83.3% for US and CT-guided techniques, whilst the lowest specificity was recorded for CT versus US-guided technique (27.8%).

Table 1: The injection criteria scores for subjective assessment of the three injection techniques for nerve block of camels head cadavers

Criteria	Score and description
Needle localization	0 = Poor, the needle not clearly localized
	1 = Good, the needle localized but not in target site
	2 = Excellent, the needle localized in target site
Correct penetration	0 = Poor, out of the target foramen
	1 = Good, in the way but not entered the target foramen
	2 = Excellent, in the target foramen
Difficulty of injection	0 = Difficult, several attempts with low confidence
	1 = Moderate, several attempts until successful injection
	2 = Easy, immediate and confident injection
Performance time	0 = 15 minute
	1 = 10 minute
	2 = 5 minute

Table 2: Effect of needle localization on the injection scores of the target nerve of the injection techniques for nerve block of camels head cadavers

Technique	Target nerve			
	Mental N.	Infraorbital N.	Supraorbital N.	Retrobulbar N.
Blind	0 (0-0)^{b}	0 (0-0)^{c}	0 (0-0)^{b}	0 (0-0)^{c}
US-guided	2 (1-2)^{a}	1 (1-2)^{b}	2 (1-2)^{a}	1 (0-2)^{b}
CT-guided	2 (0-2)^{a}	2 (1-2)^{a}	2 (2-2)^{a}	2 (1-2)^{a}

a, b, c: Medians and ranges with different superscript letters at the same column are significantly different at P<0.05.

Table 3: Effect of correct needle penetration on the injection scores of the target nerve of the injection techniques for nerve block of camels head cadavers

Technique	Target nerve			
	Mental N.	Infraorbital N.	Supraorbital N.	Retrobulbar N.
Blind	1 (0-1)^{b}	1 (0-2)^{b}	1 (0-1)^{b}	0 (0-1)^{c}
US-guided	2 (1-2)^{a}	1 (1-2)^{b}	2 (1-2)^{a}	1 (1-2)^{b}
CT-guided	2 (1-2)^{a}	2 (2-2)^{a}	2 (1-2)^{a}	2 (1-2)^{a}

a, b, c: Medians and ranges with different superscript letters at the same column are significantly different at P<0.05.

Table 4: Effect of difficulty of injection on the injection scores of the target nerve of the injection techniques for nerve block of camels head cadavers

Technique	Target nerve			
	Mental N.	Infraorbital N.	Supraorbital N.	Retrobulbar N.
Blind	1 (0-1)^{b}	1 (0-1)^{b}	0 (0-1)^{b}	0 (0-1)^{c}
US-guided	1 (1-2)^{b}	2 (1-2)^{a}	2 (1-2)^{a}	1 (1-2)^{b}
CT-guided	2 (1-2)^{a}	2 (1-2)^{a}	2 (2-2)^{a}	2 (1-2)^{a}

a, b, c: Medians and ranges with different superscript letters at the same column are significantly different at P<0.05.

Table 5: Effect of performance time on the injection scores of the target nerve of the injection techniques for nerve block of camels head cadavers

Technique	Target nerve			
	Mental N.	Infraorbital N.	Supraorbital N.	Retrobulbar N.
Blind	1 (0-1)^{b}	0 (0-1)^{c}	0 (0-1)^{c}	0 (0-1)^{c}
US-guided	2 (1-2)^{a}	1 (1-2)^{b}	1 (1-2)^{b}	1 (1-2)^{b}
CT-guided	2 (1-2)^{a}	2 (2-2)^{a}	2 (1-2)^{a}	2 (1-2)^{a}

a, b, c: Medians and ranges with different superscript letters at the same column are significantly different at P<0.05.

DISCUSSION

In the practice of veterinary anesthesia, there is a continued interest in striving for appropriate alternative nerve block procedures offering the potential of greater success based on accuracy, reliability and safety associated with needle placement in relation to the target nerve (Bagshaw *et al.,* 2009; Campoy *et al.,* 2010; Kramer *et al.,* 2014). In human medicine, most nerve block techniques have shifted to imaging-guided techniques for interventional procedures (Park and Lee, 2014; Helen *et al.,* 2015). However, finding a proper imaging modality for the nerve block in veterinary practice is a matter of controversy. Therefore, this study was planned and conducted to evaluate the applicability and feasibility of the US and CT-guided injection techniques in comparison with the blind technique for nerve block of the camel head cadavers. To the best of the authors' knowledge, this is the first study using US and CT-guided injection techniques for the camel head nerve block.

A sound anesthetic technique with a higher success rate is essential for proper head surgery in farm animals (Huichu and Walz, 2014). In the blind technique, the needle insertion is based on palpation of surface anatomic landmarks without visual control. This often results in an inability to properly localize the anatomic site for needle insertion and may result in incorrect needle placement and inadequate nerve block (Rioja *et al.*, 2012; Badawy and Eshra, 2015). For the above-mentioned reasons, this cadaveric study proposed an initial reference for the application of imaging guided injection for nerve block of the head in camel cadavers as a model for improving nerve block procedures in large ruminants.

In this study, the application of US-guided injection technique for the performance of nerve blocks showed higher scores in all injection criteria and specificity (83.3%) versus blind technique. This could be attributed to the direct noninvasive visualization of the target nerves, needle orientation and distribution of local anesthetic drug in optimal position near the nerves, which amplify the precision and reduce the blocking time and the required volume of local anesthetics. These findings were in accordance with Sites and Brull (2006), Bagshaw *et al.* (2009) and Shilo *et al.* (2010).

Imaging of orbital structures by US or CT during retrobulbar nerve block was safer to avoid penetration of eye ball and obtain the best visualization of orbital anatomy and needle insertion away from larger vessels (Osuobeni and Hamidzada, 1999; Alsafy *et al.*, 2014; Helen *et al.*, 2015). In this study, the US transducer was applied directly on the upper eye lid and the needle was forwarded under US-guidance for retrobulbar nerve block. These findings agreed with Luyet *et al.* (2008) and Morath *et al.* (2013).

Needle placement and visualization is the challenge for safe and effective US-guided nerve block technique (Sites *et al.*, 2007). Though, it is affected by several factors, including needle alignment, length, echogenicity and lack of clinical data supporting a standard technique for needle insertion (Helen *et al.*, 2015). Although our cadaveric series showed the feasibility of using US-guided injection of the head, use of ultrasound imaging may require some experience to develop a trained eye, keeping the needle tip in view advanced toward the target nerve. Failure to visualize the needle tip was the most common challenge observed with US-guided injection in our study. Therefore, we used a long and rigid 22-gauge spinal needle inserted directly close to the transducer with approximately 75° angle to the skin in relation to the investigated nerve site. In addition, to ensure adequate needle localization, we injected 2.5mL of lidocaine HCl mixed with equal volume of Iopaminol as a hydrolocation marker to confirm the needle tip location. Similar recommendations were advised by Chapman *et al.* (2006), Maecken *et al.* (2007) and Sites *et al.* (2007).

In this study, the Us-guided technique showed lower specificity versus CT-guided technique (27.8%) in the imaging guided injection for the head nerve block in camel. Despite this, it is a relatively feasible and affordable radiation-free imaging tool, easy to perform in skilled hands with minimal risks and cost-effective without special equipments under field conditions. Moreover, US-guided could easily be incorporated into a diagnostic or therapeutic procedure, especially for those animals who present with idiopathic head swellings, thus enabling US-guided block at the same time with a subsequent US evaluation performed for diagnostic or therapeutic treatment of the disease. These findings were in agreement with Marhofer *et al.* (2005) and Echeverry *et al.* (2012).

Based on the results of this study, the CT-guided injection revealed excellent spatial anatomical resolution and reconstruction, discrimination between bone and soft tissue and more precise needle placement for imaging-guided nerve block in camels head cadaver. In addition, the high specificity for this technique discriminated by the statistical analysis of the injection parameters gives it the superiority in comparison to ultrasound. On the other hand, CT-guided technique has been hampered by an inability to show the spread of contrast media, radiation hazards and by the logistics and price of imaging exceeds ultrasound or blind block technique. These results were in accordance with Park and Lee (2014) and Blanco *et al.* (2015). In nerve block techniques, the challenging limitation is the evaluation of proper needle placement in relation to the target nerve without complications. Therefore, the injection criteria score system used for evaluation of the injection techniques in this study seemed to serve well for providing a simple tool for subjective assessment of the efficacy and success rates of imaging-guided injection technique. These findings were in accordance with Rioja *et al.* (2012).

Acquiring and maintaining a feasible and efficient injection technique, a critical step for safe and accurate nerve block, can be challenging. In this study, we evaluated the US and CT-guided injection techniques in comparison with the blind ones for nerve block of the camel head cadavers. Collectively, our results demonstrated the feasibility of US and CT to visualize anatomical structures and precise needle placement during mental, infraorbital, supraorbital and retrobulbar injections in camel cadavers in comparison with the blind technique. However, each of the above-mentioned techniques has its own advantage and disadvantages. Therefore, further rigorous prospective trials are needed to assess the efficacy and safety of this technique in large number of clinical cases.

Table 6: Statistical parameters for imaging-guided injection techniques versus blind techniques discrimination for nerve block of camels head cadavers

Technique	Sensitivity (%)	Specificity (%)	Odds ratio	Confidence interval (95%)	Positive value	Negative Value	P value
US vs Blind	72.2%	83.3%	13	4.03-38.22	81.3%	75.0%	0.0001**
CT vs Blind	94.4%	83.3%	85	15.03-389	85.0%	93.8%	0.0001**
CT vs US	94.4%	27.8%	6.5	1.49-31.54	56.7%	83.3%	0.023*

*: Significant at P< 0.05 %; **: Significant at P< 0.0001 %

Limitation of this study includes the small sample size, restriction to cadaveric cases which exclude vital *in vivo* parameters as pain and movement of the animal during injection, postmortem changes to local tissues in cadaveric samples and limited experience performing US and CT-guided nerve block in veterinary practice.

Conclusions: In conclusion, the US and CT-guided injection techniques offers considerable advantages for characterization of the anatomical landmarks, needle placement and selectivity of the technique which is difficult to obtain using conventional blind technique. Furthermore, imaging guidance for regional nerve block is still in its relatively early stages and additional clinical studies are required to further evaluate the efficacy and limitations of employing this modality in veterinary practice.

Authors contribution: MH conceived and designed the experiments; EE, AA performed the experiments; EA analyzed the data and EE wrote the manuscript. All authors critically revised the manuscript for important contents and approved the final version.

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