TEACHING ULTRASOUND PROCEDURAL SKILLS-LOW COST PHANTOMS AND ANIMAL MODELS

Jacek A. Wojtczak* And Sonia Pyne**

Abstract

Acquiring the necessary cognitive and psychomotor skills to perform ultrasound guided procedures may require initial training. Growing evidence shows that simulation can help in the acquisition of procedural skills. Commercially available phantoms are expensive, have non-tissue like haptics, are preformed with fixed targets and do not allow for additional targets to be imbedded.

In this study we have described several new phantoms and animal models that are inexpensive, easy to assemble and allow a rapid change of targets. Such phantoms can provide an ideal initial learning opportunity in a zero-risk environment.

Key words: ultrasound phantoms, ultrasound-guided procedural skills.

Introductıon

Ultrasound (US) guided nerve blocks, cricothyroid punctures and vascular cannulations require, for safety reasons, initial training in animal models or phantoms. In-vitro models can facilitate learning of scanning techniques and hand-eye coordination skills. The elastomeric phantoms that are usually used for training lack tissue feedback, are expensive, rapidly deteriorate and become unusable due to needle tracks. In this study we describe new, improved animal models and phantoms that can be used in teaching ultrasound guided procedural skills.

Methods

We have prepared and evaluated low-cost phantoms (gelatin/agar or tofu bars with immersed tubular structures or plastic spine models), animal models (intact porcine heads, infrahyoid airway) and hybrid models (animal tissues immersed in gelatin or tofu, human hand placed on the foam to model lung with rib cage).

US scanning was performed using BK Medical Flex Focus 400 and Sonosite S-Series systems.

* MD, PhD, Professor of Anesthesiology.

** MD, Assistant Professor of Anesthesiology.

Affiliation: Department of Anesthesiology, University of Rochester School of Medicine and Dentistry, Rochester, New York.

Corresponding author: Jacek A. Wojtczak, MD, PhD, Professor of Anesthesiology, Department of Anesthesiology, Box 604. University of Rochester School of Medicine and Dentistry, 601 Elmwood Ave, Rochester, New York 14642. Tel: 585-275-2141, Fax: 585-244-7271. E-mail: jack_wojtczak@urmc.rochester.edu

Results

Retrobulbar blocks are usually placed blindly in awake patients without US guidance[1]. Severe complications of this blind technique have been reported. Real-time US guidance provides visualization of the eye and the optic nerve before and during insertion of the needle which can improve the quality and safety of the block. Intact porcine head models (Fig. 1) obtained in the slaughterhouse allow for supervised training to avoid ocular perforation and injection of local anesthetic into the optic nerve or sheath.

Cricothyroid membrane punctures were performed in the porcine infrahyoid airway embedded in gelatin (Fig. 2 and 3) which allowed visualization of the posterior wall of the airway.

Vascular cannulations[2] were performed in tofu models. Thin polyethylene tubings filled with saline were inserted into tofu bars (Fig. 4). Thin walls allowed easy penetration of the needle and confirmation of the successful cannulation.

Ultrasound-guided placement of the spinal needle was performed in plastic lumbar and sacral spine models[3] immersed in gelatin or water bath (Fig. 5).

Fig. 1
A *- pig eye axial sonogram (12 MHz linear probe). The lens (L) is intact and the retrobulbar area well visualized.*
B *- injection of 5 ml of saline through the needle (N) fills the orbital canal.*
Sclera and the needle tip are well visualized.

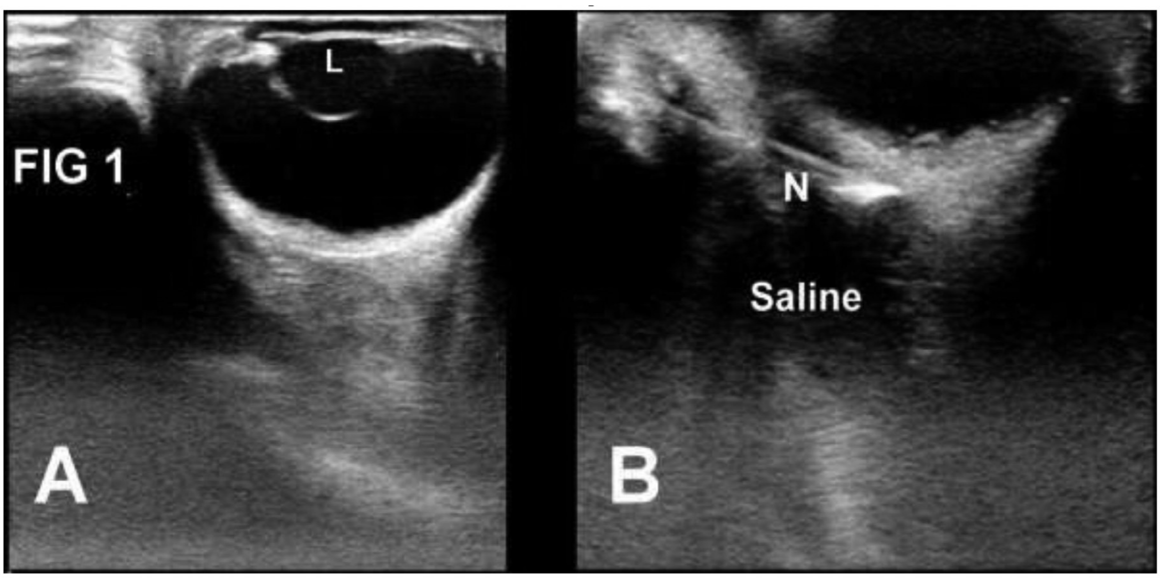


Fig. 2
A *- cross section of a pig trachea (T) and esophagus (E) embedded in gelatin.*
B *- transverse ultrasound scan of the same specimen (18 MHz linear probe).*
C *- longituinal scan of the specimen. The anterior and posterior walls of the trachea (T) are visualized. The needle was inserted through the crico-thyroid membrane.*

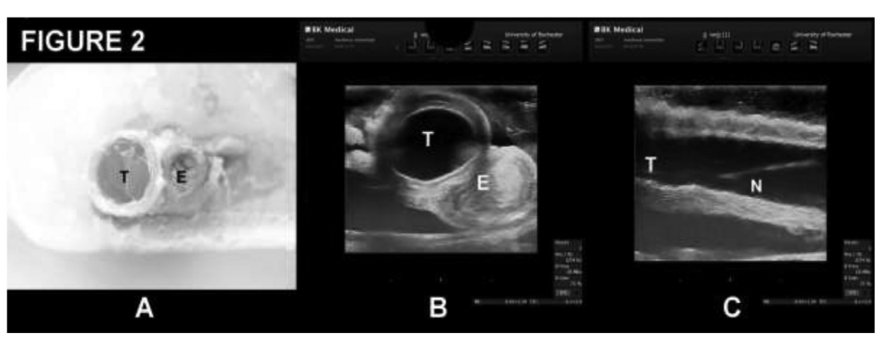


Fig. 3

Upper panels - transverse ultrasound scans of the porcine thyroid cartilage immersed in gelatin (left); porcine cricothyroid membrane puncture (right) with needle reverberation artifact. Lower panels – transverse (left) and longitudinal (right) scans of the trachea immersed in gelatin. Needle visible in the trachea.

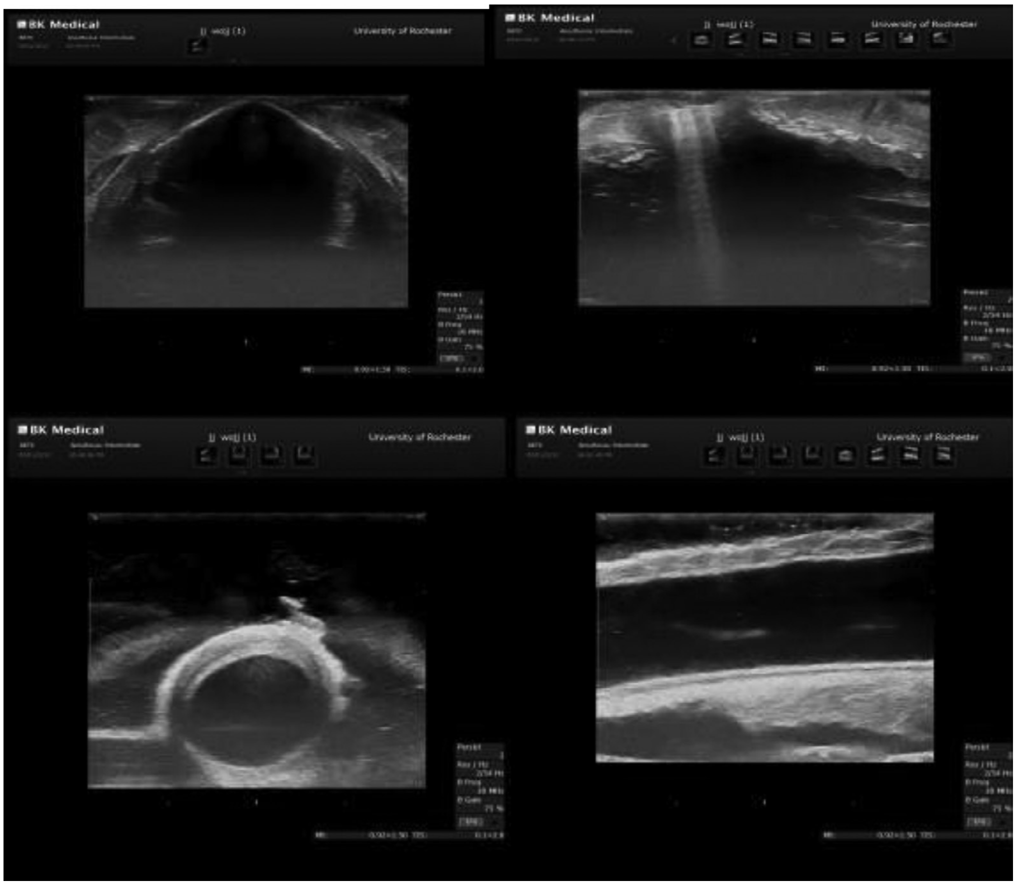


Fig. 4

Vascular puncture performed in tofu models. Polyethylene tubings filled with saline were inserted into tofu bars to mimic blood vessels.

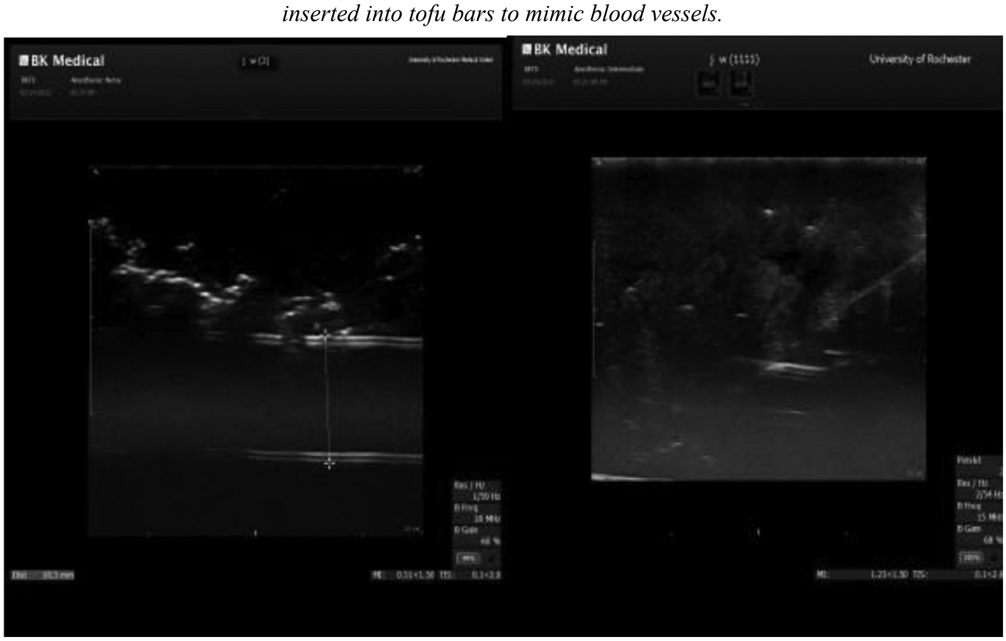
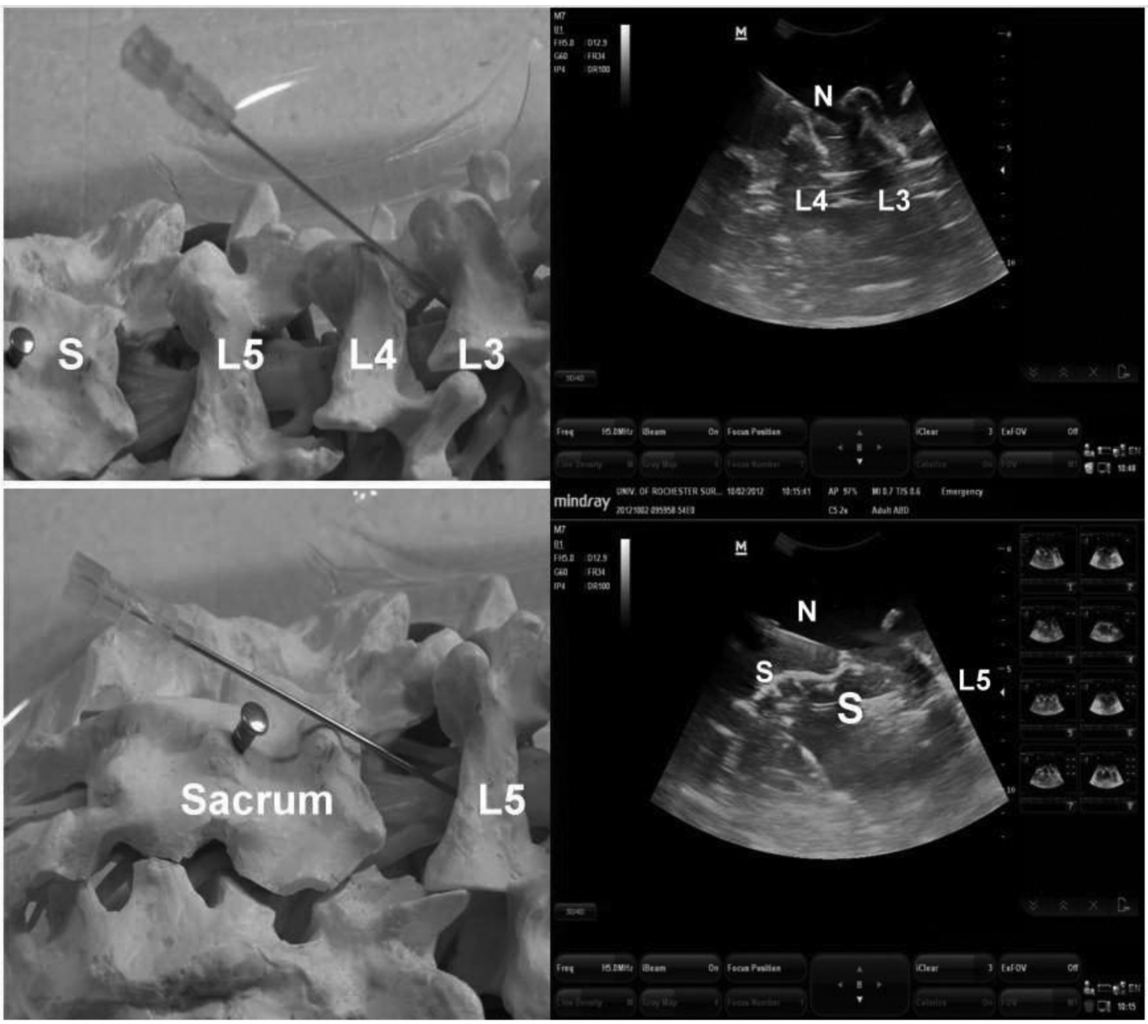


Fig. 5
Saggital paramedian ultrasound scans of the plastic spine model immersed in gelatin. Spinal needles are placed in the intervertebral space between L3 - L4 (upper panel) ***and*** *L5 - S1 (lower panel).* ***N*** *- needle;* ***S*** *- sacrum;*
L3, L4, L5 *- spinal procesess and lamina of the L3, L4, L5 vertebra.*



Ultrasound-guided thoracentesis was performed in the model consisting of the experimenter's hand placed on top of the water-filled container with a wet foam. Metacarpal bones of the human hand simulated a rib cage and a wet foam simulated a diseased lung immersed in the pleural fluid (Fig. 6).

Discussion

Ultrasound guidance improves safety, success rate and efficacy of various procedures provided that the tip of the needle is visualized at all times[4]. This skill can be taught in animal models and phantoms[5]. Optimizing the image of the needle with ultrasound beam alignment and reaching a target inside the phantom or the animal model may require a considerable number of attempts[5,6]. The cumulative sum (cusum) charts revealed[7] that novice operators acquire such abilities at variable rate. Appropriately designed models may allow for controlled, supervised learning, including a formative feedback between trials[5,8] and construction of individual learning curves. An important benefit of using animal models is that it also allows teaching of the ultrasound anatomy. Imbedding the animal tissue in gelatin or gelatin/agar mixture for improved durability of the phantom enhances the quality of the ultrasound image while preserving tissue feedback.

Fig. 6
*Hybrid model of the lung. The experimenter's hand is placed on top of the fluid-filled container with a wet foam (left panel). A sonogram (right panel) of metacarpal bones (**M**) of the human hand which simulate a rib cage and a wet foam underneath simulates a diseased lung (**L**) that is immersed in the pleural fluid (**F**). **N** - needle.*

The role of ultrasound in central neuraxial blockade has been underappreciated due to the perceived difficulty in imaging through the narrow acoustic window produced by the vertebra. However, the interlaminar window permits passage of sound waves. The intervertebral level can be identified and the depth to the epidural and intrathecal spaces can be estimated[9].

Practicing on cadavers allows participants to study the sonographic anatomy and practice sonographically guided blocks with realistic tactile feedback, but they are often limited by the quality of sonograms and have to be conducted in credentialed facilities.

In-vitro models as described in this study allow visualization of the osseous and soft tissue anatomy and can facilitate the teaching of scanning techniques and hand-eye coordination skills that are required for real-time sonographically guided blocks.

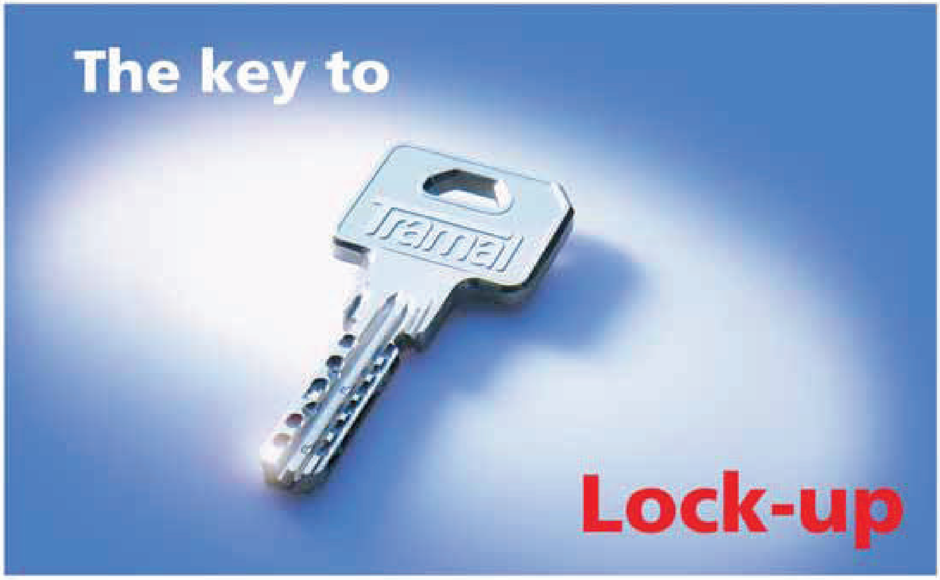
Procedural skills in the field of anesthesiology are assessed poorly compared with other domains of learning[5] as they are often given less importance than the assessment of knowledge and judgement-based skills. This is partly because there has been no universally accepted and comprehensive way to assess procedural skills. It is our goal to further develop and optimize our in-vitro models to enable an objective assessment of procedural skills by our anesthesia trainees.

Conflict Of Interest

None.

References

1. Luyet C, Eichenberger B, Morriggl L, Remada L, Greig R: Real-time visualization of ultrasound-guided retrobulbar blockade: an imaging study. *Br J Anaes;* 2008, 101:855-59.
2. Troianos C, Hartman S, Glas K, Skubas N: Guidelines for performing ultrasound cannulations. *Anesth Analg;* 2012, 114:46-72.
3. Li J, Karmakar M, Li X, Kwok W: Gelatin-agar lumbosacral spine phantom. *J Ultrasound Med;* 2011; 30:263-72.
4. Hopkins P: Ultrasound guidance as a gold standard in regional anaesthesia. *Br J Anaes;* 2007, 98:299-301.
5. Bould M, Crabtree N, Naik V: Assessment of procedural skills in anaesthesia. *Br J Anaes;* 2009, 103:472-83.
6. Sites B, Gallagher J, Cravero J, Landberg J, Blike G: The learning curve associated with a simulated ultrasound-guided interventional task by inexperienced anesthesia residents. *Reg Anesth Pain Med;* 2004, 29:544-548.
7. De Oliveira Filho G, Helayel D, Garzel P: Learing curves and mathematical models for interventional ultrasound basic skills. *Anesth Analg;* 2008, 106:568-573.
8. Raman M, Donnon T: Procedural skills education-colonoscopy as a model. *Can J Gastroenter;* 2008, 22:767-70.
9. Chin K, Karmakar M, Peng P: Ultrasonography of the adult thoracic and lumbar spine for central neuraxial blockade. *Anesthesiology;* 2011, 114:1459-85.



Postoperative Pain

STEP I

Initial bolus

Inject 1 ampoule Tramal® 100 mg i.v. or i.m. slowly over 2-3 minutes

STEP II

Ways of administration after initial bolus

Infusion[1]

Inject 2 ampoules Tramal®, each 100 mg, in 500ml of infusion solution. Infusion rate 12-24 mg Tramal®/h (10-20 drops/min or 30-60ml/h).

PCA[2]

Subsequent increments of 20 mg with a lock-out time of 5 minutes.

Injection[3]

Usual dose is 50 mg or 100 mg 4-6 hourly up to a total daily dose of 400 mg except in special clinical circumstances which might necessitate daily doses up to 600 mg. Further treatment with Tramal® boluses on demand.

If needed further doses of Tramal® 50 mg up to a total of 200 mg (including the initial bolus) within the first 60 min.

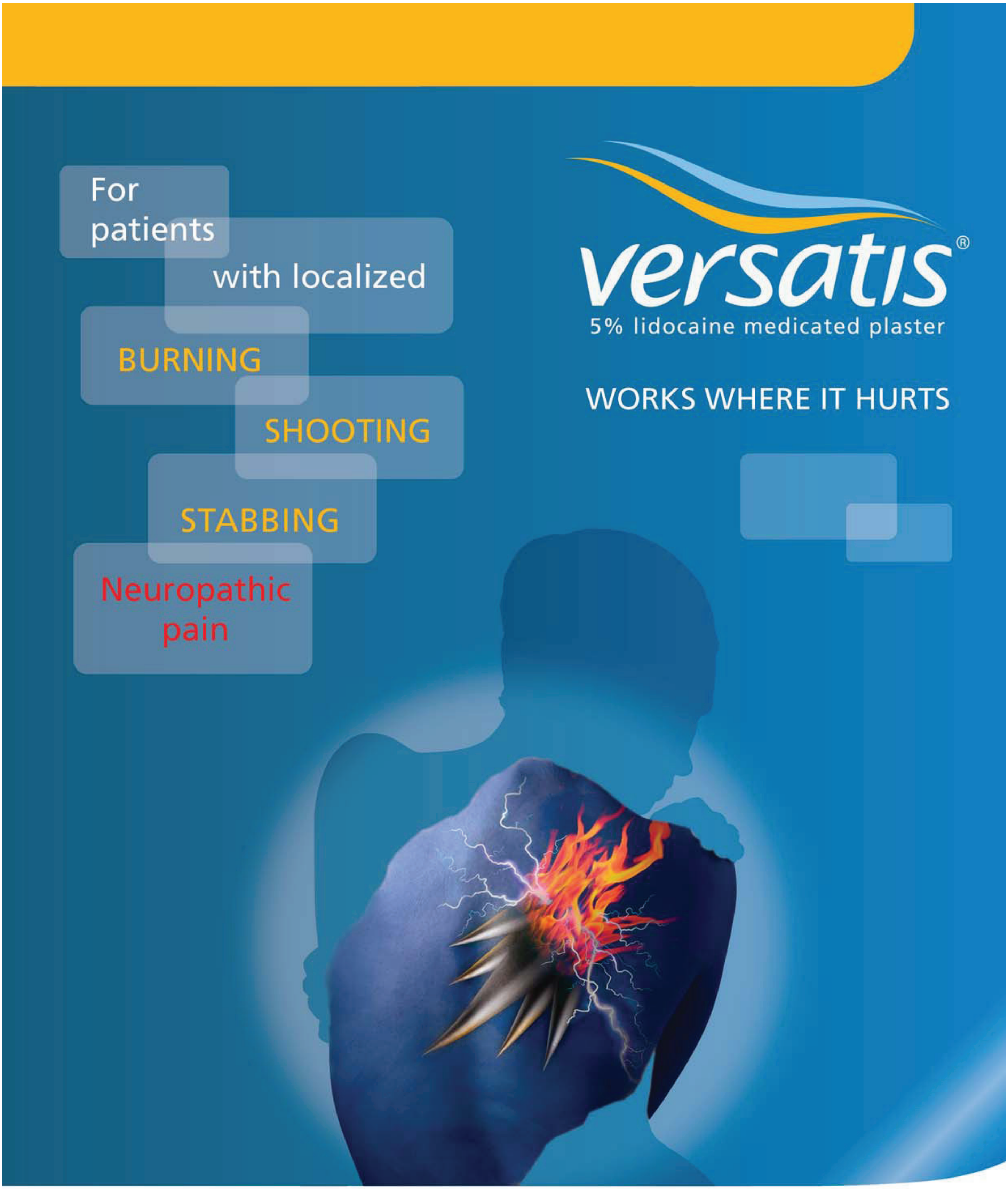
STEP III

Follow-up	50 mg	1-2 capsules	every 4-6 hours
	50 mg	20-40 drops	every 4-6 hours
	100 mg	1 suppository	every 4-6 hours
slow release	100 mg, 150 mg, 200 mg	1 tablet	every 12 hours

Intra-Operative	Post-Anaesthesia Care Unit
Loading Dose 2,5 - 3 mg/kg[2,3] at wound closure	If intra-operative dose not given then **BOLUS I.V.*** **100 mg over 2-3 mins**[3]
An intra-operative loading dose of Tramal® will reduce PONV rates[4]	*if needed further doses of 50 mg up to a total of 200mg (incl. the initial bolus) may be given within the first 60 min.

Tramal® INVENTED BY GRÜNENTHAL

1. Coetzee J.F. et al. Br.J. Aneasth 1998;81:737-741. 2. Pang W. et al. Can. J. Anesth.2000; 47: 968-973.
3. Rud U et al. Aneasthetist 1994; 43: 316-321. 4. Pang w. et al. Can. J. Anesth.2003; 50(1): 48-51.


For patients
with localized
BURNING
SHOOTING
STABBING
Neuropathic pain
versatis®
5% lidocaine medicated plaster
WORKS WHERE IT HURTS

GRUNENTHAL


versatis®
5% lidocaine medicated plaster

bridion®
sugammadex
Predictable. Complete. Rapid.

BRIDION—for **optimal neuromuscular blockade management** and improved recovery

Predictable and complete reversal

- 98% of BRIDION patients recovered to a TOF* ratio of 0.9 from reappearance of T_2‡ within 5 minutes[2]
- 97% of BRIDION patients recovered to a TOF* ratio of 0.9 from 1 to 2 PTCs † within 5 minutes[3]

Rapid reversal

- BRIDION rapidly reversed patients from reappearance of T_2‡ in 1.4 minutes[2]
- BRIDION rapidly reversed patients from 1 to 2 PTCs † in 2.7 minutes[3]

BRIDION is indicated for the reversal of neuromuscular blockade induced by rocuronium or vecuronium. In children and adolescents (aged 2-17 years), BRIDION is only recommended for routine reversal of moderate rocuronium-induced neuromuscular blockade[1]

Important safety information

BRIDION is not recommended in patients with severe renal impairment. Studies in patients with hepatic impairment have not been conducted and, therefore, patients with severe hepatic impairment should be treated with great caution. Caution should be exercised when administering BRIDION to pregnant women as no clinical data on exposed pregnancies are available.

BRIDION has not been investigated in patients receiving rocuronium or vecuronium in the Intensive Care Unit (ICU) setting.

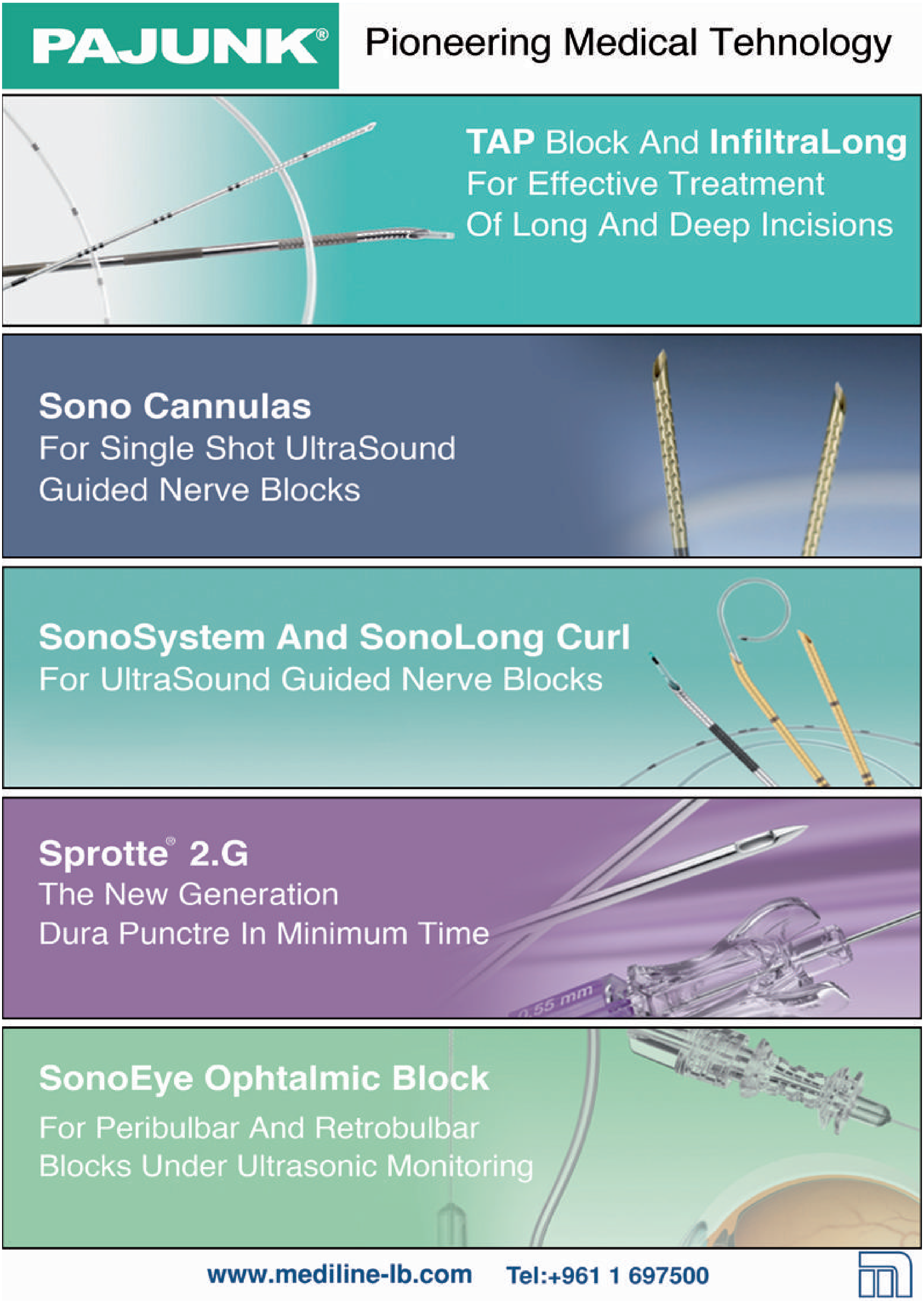
If neuromuscular blockade is required within 24 hours of BRIDION administration, a nonsteroidal neuromuscular blocking agent should be used instead of rocuronium or vecuronium. The most commonly reported adverse reactions were dysgeusia (metal or bitter taste) and anesthetic complications (movement, coughing, grimacing, or suckling on the endotracheal tube). In patients treated with BRIDION, a few cases of awareness were reported. The relation to BRIDION was uncertain. In a few individuals, allergic-like reactions (ie, flushing, erythematous rash) following BRIDION were reported. Clinicians should be prepared for the possibility of allergic reactions and take the necessary precautions. In a trial of patients with a history of pulmonary complications, bronchospasm was reported in 2 patients and a causal relationship could not be fully excluded. Volunteer studies have demonstrated a slight (17%-22%) and transient (<30 minutes) prolongation of the prothrombin time/activated partial thromboplastin time (PT/aPTT) with BRIDION; however, clinical studies have demonstrated no clinically relevant effect on peri- or postoperative bleeding complications with BRIDION alone or in combination with anticoagulants. As BRIDION has demonstrated an in vitro pharmacodynamic interaction with anticoagulants, caution should be exercised in patients on anticoagulation for a pre-existing or comorbid condition. This pharmacodynamic interaction is not clinically relevant for patients receiving routine postoperative prophylactic anticoagulation. Although formal interaction studies have not been conducted, no drug interactions were observed in clinical trials. Preclinical data suggest that clinically significant drug interactions are unlikely with the possible exceptions of toremifene, fusidic acid, and hormonal contraceptives.

* Train of four
† Post-tetanic counts
‡ Second twitch

REFERENCES: 1. BRIDION Summary of Product Characteristics (SPC) **2.** Blobner M, Eriksson LI, Scholz J, Motsch J, Della Rocca G, Prins ME. Reversal of rocuronium induced neuromuscular blockade with sugammadex compared with neostigmine during sevoflurane anaesthesia: results of a randomised, controlled trial. [published online ahead of print July 30, 2010]. Eur J Anaesthesiol. doi:10.1097/EJA.0b013e32833d56b7.
3. Jones RK, Caldwell JE, Brull SJ, Soto RG. Reversal of profound rocuronium-induced blockade with sugammadex: a randomized comparison with neostigmine. Anesthesiology. 2008,109(5):816-824.

Please see summary of product characteristics for full prescribing information.

MSD
Be Well


PAJUNK®
Pioneering Medical Tehnology
TAP Block And InfiltraLong
For Effective Treatment
Of Long And Deep Incisions
Sono Cannulas
For Single Shot UltraSound
Guided Nerve Blocks
SonoSystem And SonoLong Curl
For UltraSound Guided Nerve Blocks
Sprotte® 2.G
The New Generation
Dura Punctre In Minimum Time
0.55 mm
SonoEye Ophtalmic Block
For Peribulbar And Retrobulbar
Blocks Under Ultrasonic Monitoring
www.mediline-lb.com
Tel:+961 1 697500