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Effect of local anesthesia on facial nerve blood flow and muscle action potential

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ABSTRACT

Background & objective: The effect of direct application of local lidocaine with epinephrine on the facial nerve (FN) has not been reported. The aim of this study is to assess the effects of 2% lidocaine with 1:100,000 epinephrine at clinically relevant concentrations in a rat FN model with respect to facial nerve blood flow (FNBF) and subsequent electrophysiological changes.
Materials and methods: To assess the influence of drugs on FNBF and electrically evoked muscle action potential (EMAP), small pieces of gelfoam were soaked in PBS 100 μl (n = 5, control group), 50 μl (n = 5, treatment group A) and 100 μl (n = 5, group B) of 2% lidocaine with 1:100,000 epinephrine, and 50 μl (n = 5, group C) and 100 μl (n = 5, group D) of 2% lidocaine. After 5 min of stable recordings, we applied a 2% lidocaine with or without 1:100,000 epinephrine impregnated gelfoam over the main trunk of the facial nerve of rats for 30 min. After removing the applied gelfoam, FNBF and threshold of EMAP were measured separately in each group.
Results: Compared to the control group, the treatment groups showed a significant reduction in FNBF in a dose-dependent manner. The maximal reductions in FNBF were observed in all treatment groups for a period after 10 min of the application. Synergistic reduction in FNBF was greater in groups A and B than in the lidocaine applied groups (C and D). The maximal increase in the EMAP threshold was observed immediately after the respective drug application in all groups. The greatest increase in the EMAP threshold was observed in group B. The increased EMAP threshold returned to the baseline value within 120 min in groups A and C.
Conclusion: From these results, it can be considered that the topical application of lidocaine with epinephrine caused reduction in FNBF and elevation of EMAP threshold. These acute reductions in FNBF and elevations in the EMAP threshold were restored in a time-dependent manner.

1. Introduction

Tympanoplasty or mastoidectomy is performed under general anesthesia. In addition, infiltration of a local anesthetic (1% lidocaine with 1:100,000 epinephrine) into the ear canal and the graft site is preferred. The rationale for this is to reduce operative bleeding and to facilitate dissection in the correct plane, particularly when elevating meatal skin flaps.

Immediate postoperative facial paralysis following middle-ear surgery is usually related to the local anesthetic if this has been added to general anesthesia [1]. The formulation of 2% lidocaine with 1:100,000 epinephrine provides excellent hemostatic action by decreasing tissue perfusion in the region of injection. The anterior ear canal injections are in close proximity to the peripheral facial trunk or its branches, and they may cause temporary weakness [2]. At times, the topical effect of local anaesthesia instilled into the middle-ear cleft on a dehiscent FN may result in transient facial paralysis. Ischemia is one of the causative mechanisms. This may result from changes in facial nerve blood flow (FNBF) caused by infiltration of the local anesthetic. Peripheral nerve such as the FN has a dual blood

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supply of intrinsic exchange vessels in the endoneurium and an extrinsic plexus of supply vessels in the epineural space that cross the perineurium to anastomose with the intrinsic circulation. The extrinsic supply (vaso nervorum) is known to be able to respond to adrenergic stimuli [3]. Although the anatomy of the vasculature supplying FN is well known, little is known about the dynamics of FNBF.

To date, there are no reports on the FNBF and muscle action potential after topical administration of the combination of epinephrine and lidocaine. So far, these parameters have mainly been studied in other peripheral nerves such as the sciatic nerve [3,4]. After subcutaneous injection or topical administration of the combination of lidocaine with epinephrine, blood flow in other peripheral nerves varied, with reports of both increases [5] and decreases [6,7] in blood flow.

The purpose of this study was to assess the effects of 2% lidocaine with 1:100,000 epinephrine in a rat facial nerve model with respect to FNBF and subsequent electrophysiological changes.

2. Materials and methods

2.1. Animals

Studies were carried out in 25 adult Sprague-Dawley rats, weighing 250–300 g. Animals were anesthetized by intraperitoneal injection of Zoletil® (a 1:1 combination of tiletamine and zolazepam, Virbac, Carros, France) and xylazine hydrochloride.

2.2. FNBF measurement

After shaving the infra-auricular area, a postauricular incision was made on the left side. Under a surgical microscope, the main trunk of the FN was exposed, at its exit from the stylomastoid foramen, before branching of the main trunk, on a temperature controlled pad set at 37 °C. The main trunk was identified by electrical stimulation for the entire hemifacial movement. Regional FNBF was then measured using laser Doppler blood flowmeter. The femoral artery was cannulated and connected to a pressure transducer (AD Instruments, Castle Hill, Australia) for measuring arterial blood pressure. A 1.0 mm needle probe of a laser Doppler blood flow meter (moorLAB, Moor Instruments, Axminster, Devon, UK) was placed on the main trunk of the FN. Extreme care was taken to avoid direct injury to the epineural circulation. FNBF measurements were made with the probe placed just over the epineural surface of the FN with care taken not to compress surface vessels or stretch the nerve with excessive retraction. The FNBF output and systemic blood pressure (SBP) data were sampled every 20 s and were analyzed by a computer equipped with a data acquisition program (PowerLab, AD Instruments). To assess the influence of anesthetics on FNBF, small pieces of gelfoam were soaked in phosphate buffered saline (PBS) 100 μl ($n = 5$, control group), 50 μl ($n = 5$, treatment group A) and 100 μl ($n = 5$, treatment group B) of 2% lidocaine with 1:100,000 epinephrine (Yuhan Co., Seoul, Korea) impregnated gefoams, and 50 μl ($n = 5$, group treatment group C) and 100 μl ($n = 5$, treatment group D) of 2% lidocaine was soaked with same amount of gelfoam. After 5 min of stable recordings, each group of impregnated gelfoam was applied over the main trunk of the FN of rats for 30 min. The FNBF was recorded for 50 min.

2.3. Electrically evoked muscle action potential

Electrophysiological analysis was performed before and after topical application in 2 animals from each of the five groups. The monopolar stimulating electrode (Xomed-Treace, Jacksonville, FL, USA) was connected to a pulse generator (A-320D, World Precision Instruments Inc., Sarasota, FL, USA), and then electrical signals (rectangular current pulse of 0.05-ms duration) were delivered to the main trunk of the FN. The monopolar stimulating electrode was secured by using a micro-manipulator. The entire probe and the flexible wire were insulated, except for the 0.5-mm ball on the end, in order to achieve localized stimulation. To record the electrically evoked muscle action potential (EMAP) signals, a needle electrode was inserted, percutaneously, into the midpoint of the left orbicularis oculi muscle. A second needle electrode was positioned subcutaneously, over the left orbicularis oris muscle. One ground needle electrode was inserted into the superficial muscle layer, near the skin. All muscle action potentials were obtained by supramaximal nerve stimulation, and the data was digitized by an acquisition system (PowerLab, AD Instruments, Castle Hill, Australia), which was displayed on a computer monitor, and analyzed using Scope software (AD Instruments, Castle Hill, Australia). The peak amplitude and latency of the action potential waveform were determined to assess the FN. Conduction velocities were calculated from the derived latencies, as well as the measured distance between the stimulus and recording probes.

The means and standard errors of SBP, FNBF, and EMAP for each experimental group were calculated at each experimental time-point. The statistical significance between the PBS control group and experimental groups was obtained using nonparametric analysis with the Wilcoxon rank sum test. $p < 0.05$ was considered statistically significant.

3. Results

3.1. FNBF

The SBP in all treatment groups was decreased maximally after 10 min but it was restored at 40 min. When SBP in each treatment group was compared to that in the control group, no statistically significant difference was found (Table 1). Compared with the control group, the treatment groups showed a significant reduction in FNBF in a dose-dependent manner (Fig. 1). The maximal reductions in FNBF were observed in all treatment groups for a period after 10 min. The greatest decrease in FNBF was 38% (group A), and decreased by turns 35.7% (group B), 47% (group C), and 52% (group D). There was a gradual increase in the FNBF within 50 min. When FNBF in each treatment group was compared with that in the control group, all treatment groups showed a statistically significant difference except at 50 min ($p < 0.05$). The decreases in FNBF were greater in the lidocaine with epinephrine groups A and B compared with the lidocaine groups C and D. The combination of lidocaine and epinephrine resulted in a synergistic reduction in the FNBF at the same lidocaine concentrations.

3.2. Facial nerve EMAP

The results for the amplitude measurements are shown in Fig. 2. The maximal increase in the EMAP threshold was observed at 10 min after the application in all treatment groups, with the greatest increase in EMAP threshold being observed in group B. The

Table 1
Mean changes in systemic blood pressure (SBP) observed during 50 min of anesthetic treatment.

Parameters (min)	Basal	10	20	30	40	50
Control	100	100	99	99	99	100
Group A	100	97	98	98	101	102
Group B	100	96	97	98	100	100
Group C	100	95	97	99	101	102
Group D	100	91	91	96	99	101