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An Assessment of the Benefit of Surgical Face Masks in Preventing Aerosol Droplet Spread during a Simulated Spinal Anaesthetic-a Blinded *in vitro* Study

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Authors' contributions

This work was carried out in collaboration between all authors. Author AB designed the study, wrote the protocol, and wrote the first draft of the manuscript. Author SOR supervised the study, helping with writing the manuscript. Author JS helped us with the statistics and collaborating the results. Authors DB and NOC helped us with microbiological section of the study, identifying the growth in agar plates. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The purpose of this study was to assess the benefit of wearing a surgical face mask in reducing aerosol contamination of agar plates in a simulated spinal anaesthetic. The contamination of plates with virulent organisms, association of growth with recent upper respiratory tract infection and food intake were also studied.
Methods: A poster containing written text was fixed to a wall, with a standard agar plate suspended at its midpoint. Each volunteer (n=30) then read the text from the wall chart to simulate verbal interaction with a patient during a spinal anaesthetic, initially wearing a surgical mask and

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then once again without a mask.
Results: This study revealed an increased risk (p =0.006) of bacterial growth on agar plates when not wearing a surgical face mask. Results also suggest that eating prior to surgical procedures may increase the risk of contamination of the surgical field in the absence of a barrier mask

Keywords: Facemasks; oral commensals; meningitis.

1. INTRODUCTION

Although rare, infectious complications from regional anaesthesia can be devastating. Incidence rates for infectious complications vary substantially between studies, ranging from 3.7 to 7.2/100,000 for spinal anaesthesia-associated meningitis and from 0.2 to 83/100,000 for epidural anaesthesia-associated epidural abscesses [1]. Various strains of α haemolytic streptococci have been reported as causative organisms of post lumbar puncture meningitis [2-4]. These strains are normal nasopharyngeal and oral commensals with very low virulence but once exposed to the cerebrospinal fluid they multiply rapidly to full blown meningitis within days [5].

Although current recommended practice is to wear a surgical face mask when performing central neuraxial blockade to prevent infective complications [6-10], little evidence exists that wearing a face mask reduces the incidence of post lumbar puncture meningitis [11,10].

The purpose of this study was to assess whether wearing a surgical face mask in a simulated spinal anaesthetic environment, reduced aerosol contamination of microbiological agar plates. Oral microbial flora can change significantly with upper respiratory tract infection (URTI) and also with recent food intake, this association was studied as a secondary end point.

2. METHODS

With Institutional ethical approval thirty healthy volunteers were enrolled from our theatre department staff. All recruits were clinical health care workers experienced in applying and wearing barrier face masks (3 ply disposable face masks, OPTIPRO, Shanghai, China). All volunteers were informed about the purpose of the study and written consent was obtained before inclusion. No specific exclusion criteria were considered.

A printed poster (size A3) containing written text was fixed to a wall in a vacant cleaned theatre with an air flow exchange of twenty times per hour. A centre blank portion was removed, into which a standard agar plate was fixed with adhesive tape. Volunteers were asked to sit on a height adjustable stool with their mouths level with the centre of the agar plate. The stool was a fixed distance of 30 cm from the wall chart and plate.

Each volunteer then read the text from the wall chart “out loud” to simulate verbal interaction with a patient during a neuraxial block. Initially the volunteer performed the study wearing a mask (control) and then repeated the performance without wearing a mask (study). Each was asked to read at a steady rate and asked to repeat until fifteen minutes elapsed for each performance. Agar plates were changed (wearing sterile gloves each time) between performances and masks were applied after each volunteer had washed their hands in a sterile fashion (five minute surgical scrub using chlorhexidine hand wash). Plates when removed were labelled using a random number system and the examining microbiologists were blinded to control and study groupings.

Columbia blood agar plates were used for the study. The agar plates were incubated in 5% CO2 (rest aerobic) environment for 48 hours at a temperature of 35 C – 37 C. The plates were examined for the presence of colony forming units and these results were recorded. The organisms present were identified using standard microbiological identification techniques as employed on a daily basis in the clinical laboratory for the identification of such organisms from clinical and environmental samples.

Prior to the study volunteers were questioned as to whether they had consumed food in the preceding thirty minutes and the presence of symptoms of an URTI within two weeks of that date.

During the performance of the study the theatre environment was maintained constant with the volunteer present solely with a single investigator. The investigator wore a surgical

mask which was changed at fifteen minute intervals and stood at a distance of twenty feet from the plates during the study. A neutral agar plate was hung on a separate wall in the theatre throughout the study performance and was changed every four hours. Four such plates were created during the study and also went in a blinded fashion for culture.

A group of 30 subjects was required for a power of eighty to achieve a significance of $p<0.05$. Mann Whitney's test was performed between all groups to see whether the differences were significant and an ANOVA test was performed to adjust for possible confounders. For more than 2 groups the Krukal-Wallis test was used.

3. RESULTS

A total of 64 agar plates were cultured in a blinded fashion by the investigating microbiology service, 30 study, 30 control and 4 ambient air neutral plates. No volunteers or plates were excluded and subjects were comparable between groups for age and gender, (Table 1). The blinding process and numbering of plates led to data being analysed as independent groups.

Twelve of the thirty agar plates in the group not wearing face masks (study group) had bacterial colony forming unit when compared with three of the thirty in group wearing face masks (control group), Fig. 1. When the distributions were tested as independent groups using the Mann Whitney U test they were significantly different (p=0.006), that is the number of colonies in unmasked volunteers was significantly higher than the number of colonies in masked volunteers. Median with mask = 0, IQR (0.0) and median without mask = 0, IQR (0,1).

All bacteria grown by culture techniques were non-pathogenic commensal bacteria (Table 2).

No multi-drug-resistant bacteria were cultured. The numbers of colony growths were analysed comparing recent infection to bacterial growth with a higher number of colonies in the group with no recent URTIs, but with no demonstrable difference between groups when the Mann Whitney U Test was applied,(p=0.966), (Fig. 2).

When the number of colonies was tested between food intake groups, growths were greater in the recent food intake group which was demonstrated to be almost significant by the Mann Whitney U test (p=0.082), median with mask = 0, IQR (0.0) and median without mask = 0, IQR(0,1), Fig. 3.

Table 1. Characteristics of study volunteers, n= number

Total volunteer	N= 30
Male:Female	56.67% (N=17) : 43.33% (N=13)
Age	
Median male age	35
Interquartile rage	9
Median female age	37
Interquartile range	12
Doctors	56.67% (N=17)
Nurses	26.66% (N=8)
Allied health care prefessional	16.66% (N=5)

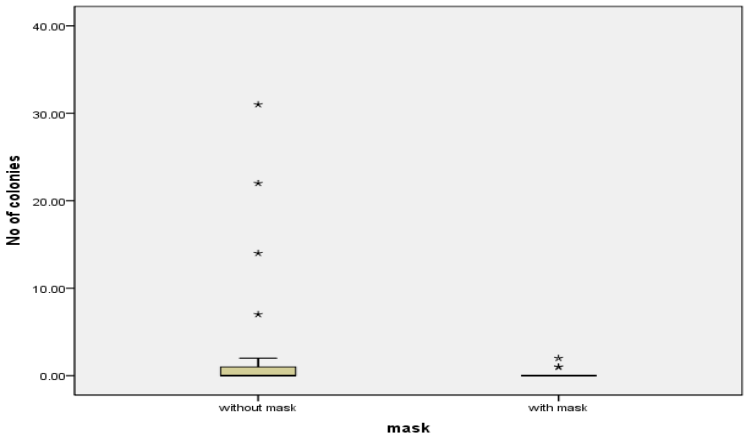

Fig. 1. Box plot demonstrating the number of colony forming units on microbiological agar plates in study (non-mask) group and control (wearing mask) group

Table 2. Bacterial species isolated on microbiological culture

Type of organism	Number of colony forming units
Coagulase negative staphylococcus	40.74% (N=11)
Alpha haemolytic Streptococci	18.51% (N=5)
Commensal Neisseria Species	11.11% (N=3)
Bacillus species (not B. Cereus)	7.40% (N=2)
Others	22.22% (N= 6)
Corynebacterium species (diphtheroids)	14.81% (N=4)

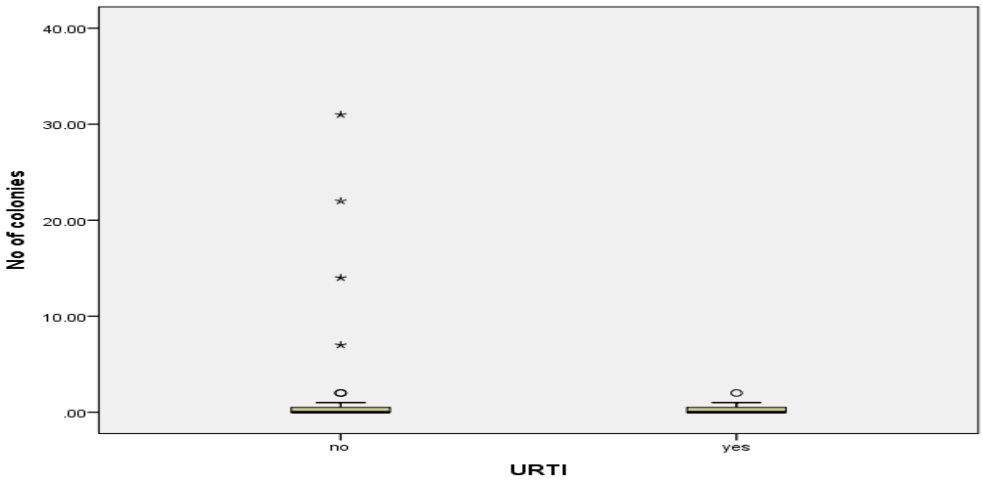

Fig. 2. Box plot demonstrating colony forming unit growth in both study groups based on recent upper respiratory tract infection (yes) or (no) recent infection

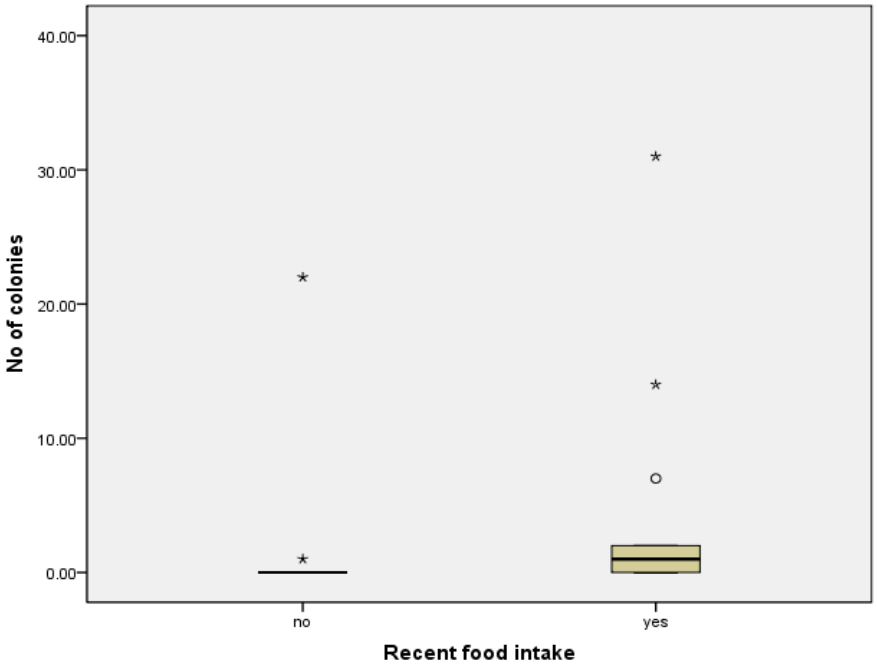

Fig. 3. Box plot demonstrating colony forming unit growth in both study groups based on recent food intake (yes) or not (no)

Exploratory analyses were carried out using ANOVAs to test whether the number of colony forming units was significantly different between facemask groups, while adjusting for recent URTIs and food intake. When adjusted the difference between the facemask groups became non-significant suggesting these were confounding factors.

Subgroup analysis of participants further separated into groups where they did or did not have an URTI and/or food revealed differences between groups. Applying the Kruskal-Wallis test to the without facemask group when the number of colony forming units were tested the differences were significant (p=0.037). Subjects with food intake tend to have higher numbers of colonies, (Fig. 4). Median number for group with neither URTI or food intake = 0, IQR (0,0), Median for food intake only group = 1, IQR(0, 5.75). Median for group with both URTI and food intake = 0.5, IQR (0, 1,75).

There was no growth on the four neutral agar plates exposed to the surrounding air, suggesting no effect on the results secondary to environmental contamination.

4. DISCUSSION

In this study, bacterial growth on blood agar plates was significantly greater in the group not wearing surgical facemasks when performing a simulated neuraxial block. The presence of bacterial growth was higher when face masks were not worn. This data suggests that the wearing of masks should reduce the risk of infection to patients by preventing droplet contamination of the sterile field [12,8,9,10]. Of significant importance was that all colonised bacteria were deemed to be “non-pathogenic” with the majority of cultured bacteria being coagulase negative staphylococci (CoNS). While not a common cause of meningitis, CoNS in one study was the causative bacteria in 11% of cases of adult meningitis [13]. In all cases a disrupted barrier of the central nervous system was present which would be in keeping with the situation present during a neuraxial block.

The ecological conditions within the mouth are dependent on a number of variables with transient fluctuations influenced by both frequency and type of food ingested [14].

In addition recent food intake may influence quantity and thus microbiological consistency of saliva potentially increasing the quantity of droplet spread and dispersion during surgical procedures. We demonstrated a potentially significant trend towards increased bacterial colonisation in the subjects tested within thirty minutes of recent food ingestion. The type of food ingested was not noted but the results suggest that eating prior to surgical procedures may increase the risk of contamination of the surgical field in the absence of a barrier mask

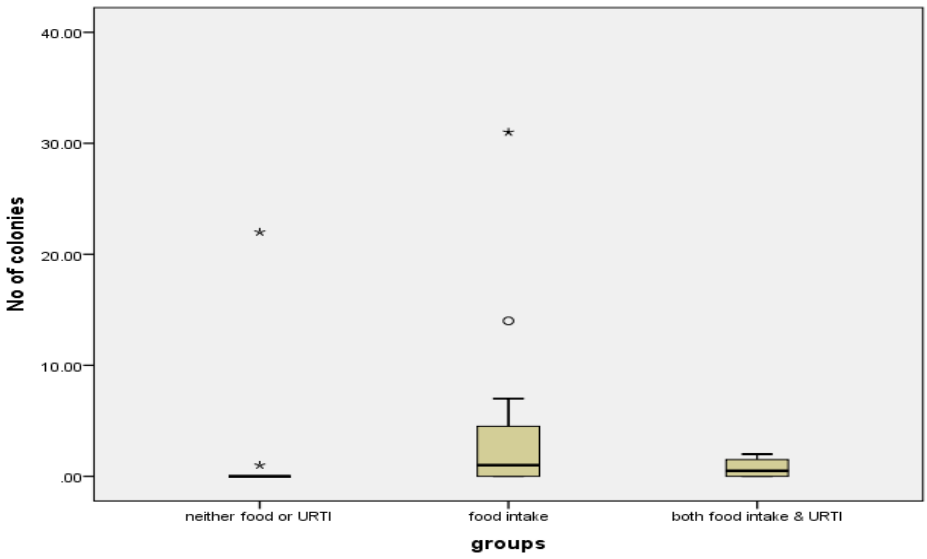

Fig. 4. Box plot: Subgroup analysis of subjects not wearing facemasks and growth of colony forming unit

It is well documented that during speech or coughing that the mouth can expel a number of different sized droplets to the surrounding environment as an aerosol. Interestingly in our group studied, presence of an URTI in the preceding two weeks did not influence increased bacterial spread.

In this study while every effort was made to simulate the conditions of a neuraxial block, it was not identical to a real anaesthetist- patient encounter. Particularly the method selected with volunteers speaking continuously while in proximity to the agar plates might not be the practice of all anaesthetists. Many anaesthetists may not speak during such a procedure, both reducing the spread of droplets and also keeping the face mask drier and maintaining a more effective barrier for a longer period. In addition while the data relating to recent food intake and recent URTI may suggest a causal effect on increased bacterial growth, it should be noted the study was powered for mask/non- mask wearing and bacterial growth alone.

5. CONCLUSION

Aerosol droplet spread is a definitive source of healthcare associated infection [15-17]. There is increased risk of spread if we are in close proximity to surgical or interventional site but wearing face mask in operating room or wards may not have any influence on droplet infection [11,10]. Our study supports previous evidence in this area [5], which recommend the wearing of face masks by personnel involved in the practice of accessing the spinal meninges by injection.

While the virulence of the bacteria demonstrated in this study was low with no multi-resistant species transferred to the “patient” surface, this risk could be reduced even further if medical personnel performing such injections wear a simple barrier face mask.

ETHICAL APPROVAL

Ethical approval was issued by the chair person, Ethical Committee Board, University of Limerick.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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