Risk factors that increase the chance of hearing loss in patients with *Streptococcus suis* infection in Uttaradit hospital, Thailand

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Abstract

Objective: To study the risk factors that increase the chance of hearing loss in a patient with *Streptococcus suis* infection in Uttaradit hospital, Thailand, *Streptococcus suis* infection tends to increase constantly, particularly in Uttaradit province which has been ranked the second place in numbers of infected patients who also face the chance of hearing loss.

Methodology: A retrospective case-control study. Data was taken from medical records and audiograms of the patients who visited Uttaradit hospital between 1 January 2009 to 31 October 2019 and were first diagnosed as *Streptococcus suis* infection with the evidence of auditory examination. 92 patients were chosen and divided into study group and control group. Study group consisted of 38 patients with sensorineural hearing loss or mixed hearing loss. Another 54 patients with no hearing loss or conductive hearing loss are classified as a control group. Group classification is done using the descriptive and analytic statistics. Results and Discussion: The results revealed that if dyslipidemia and meningitis were associated, the chance of hearing loss will increase significantly for 28.7 (95%CI=1.20-685.18, p=0.038) and 8.2 (95%CI=1.99-14.19, p=0.004) times, respectively. In contrast, hypertension, male and kidney disease have no significant effect with an increasing chance of only 2.1
(95%CI=0.59-7.80, p=0.250), 1.8 (95%CI=0.38-8.68, p=0.457) and 1.4 (95%CI=0.30-6.21, p=0.684) times, respectively. The limitation of this study is the capability to control variables and adequate sample size. Conclusions: The patients with *Streptococcus suis* infection and dyslipidemia and/or meningitis have increased the risk of hearing loss. Therefore, the surveillance of these patients is strongly recommended in order to decrease the chance of hearing loss.

Keywords: *Streptococcus suis, Hearing loss, Risk factor*

1. Introduction

Streptococcus suis is a pathogen which transmitted from animal to human mainly through the wound and exposure to pigs or pork including raw pork consumption (Goyette-Desjardins, Auger, Xu, Segura, & Gottschalk, 2014; Rayanakorn, Goh, Lee, Khan, & Saokaew, 2018). It is mostly found in nasal cavities and tonsils. In 1968, the first infected human was reported in Denmark (Kidchana, Meekhanon, Hatrongjit, Gottschalk, & Kerdsin, 2019). In 2016, 2017 and 2018, the prevalence in Thailand is 300, 317 and 338, respectively (Ministry of Thailand Public Health. 2019). These numbers indicated that the prevalence has been increasing constantly (Huong et al., 2014). It is found that the Northern part of Thailand has the highest prevalence which is about 73% and Uttaradit is the second-highest after Nakornsawan (Ministry of Thailand Public Health. 2019). Currently, there is a literature that reports the factors contributing to *Streptococcus suis* infection, which included gender, occupation, alcohol drinking and underlying diseases such as meningitis, liver disease, etc (Rayanakorn et al., 2018). The complications of this infection are including meningitis (68%) (Seele et al., 2018) and hearing loss (53%) (van Samkar, Brouwer, Schultsz, van der Ende, & van de Beek, 2015).These complications are a common sequelae and mostly irreversible. A serious complication could lead to death with a mortality rate of about 13% (Seele et al., 2018). In addition, it has been reported that the factors that affects the chance of sensorineural hearing loss in the general population are age (Frisina, Ding, Zhu, & Walton, 2016), gender (Im et al., 2018), dyslipidemia, diabetes mellitus, hypertension (Zhang et al., 2019), kidney disease (Meena, Aseri, Singh, & Verma, 2012), anemia (Mohammed et al., 2019), cerebrovascular events (Koohi, Vickers, Utoomprurkporn, Werring, & Bamiou, 2019), smoking, and alcohol drinking (Dawes et al., 2014).

The finding of the previous literature indicated that not all hearing loss patients are caused by meningitis (Huong et al., 2019). Therefore, this study aimed to study the risk factors in *Streptococcus suis* infection patients based on the factors that affect hearing impairment in general population in order to enhance the effectiveness in surveillance of *Streptococcus suis* infection patients.

2. Objective

To study the risk factors that increase the chance of hearing loss in patient with *streptococcus suis* infection in Uttaradit hospital.

3. Materials and Methods

Study design: A retrospective case-control study

Study period: 1 January 2009 – 31 October 2019

Sampling frame: Group of *Streptococcus suis* infection patients with sensorineural or mixed hearing loss and without hearing loss or conductive hearing loss who visited Uttaradit hospital between 1 January 2009 to 31 October 2019 and were first diagnosed as *Streptococcus suis* infection at Uttaradit hospital.

Study criteria:

Inclusion criteria

Patients who were first diagnosed as *Streptococcus suis* infection and visited Uttaradit hospital between 1 January 2009 to 31 October 2019.

Exclusion criteria

1. Patients who do not have *Streptococcus suis* infection.
2. Patients who had incomplete data in the database.
3. Patients who had previous hearing loss.
4. Patients who didn't have the evidence of auditory examination.

Case: Group of S*treptococcus suis* infection patients with sensorineural or mixed hearing loss who were first diagnosed between 1 January 2009 – 31 October 2019.

Control: Group of *Streptococcus suis* patients with no hearing loss or conductive hearing loss who were first diagnosed between 1 January 2009 – 31 October 2019.

Source: Data from medical records in the ICD-10 system and audiogram in Uttaradit hospital.

Variables:

Independent variable: gender, age, alcohol drinking, smoking, diabetes mellitus, hypertension, cerebrovascular events, anemia, dyslipidemia, kidney disease, and meningitis

Dependent variable: *Streptococcus suis* infection patients with hearing loss.

Statistical analysis:

Descriptive statistics: Analyze categorical data by comparing the number and percent of the data by Fisher's exact test or Chi-square method

Analytical statistics: Analyze relative risk by univariate and multivariate logistic regression analysis presented in Odd ratio, 95% CI and p-value by using Fisher's exact test or Chi-square method.

4. Results and Discussion

From the study of general characteristics in 92 *Streptococcus suis* infection patients in Uttaradit hospital,38 patients as a case and 54 patients as a control. Majority of patients are male (84.2%), age above 60 (52.6%), alcohol drinking (63.2%), smoking (36.8%), hypertension (40.5%), cerebrovascular events (7.9%), dyslipidemia (18.9%), kidney disease (15.8%) and meningitis (86.8%). (Table 1.)

The relative risk of hearing loss from a univariable logistic regression study found that dyslipidemia and meningitis can significantly increase the risk by 6.1 (95%CI 1.04–62.26, p=0.028) and 5.2 (95%CI 1.63 – 19.58, p=0.002) times, respectively. While male with alcohol drinking, hypertension and cerebrovascular events have no significant increase of only 1.5 (95%CI 0.46-5.48, p= 0.595), 1.3 (95%CI 0.51-3.38, p=0.663), 2.6 (95%CI 0.79-5.87, p=0.110) and 1.5 (95%CI 0.18 – 11.47, p=0.688) times, respectively. (Table 2.)

The relative risk of hearing loss from a multivariable logistic regression study found that dyslipidemia and meningitis can significantly increase the risk of 28.7 (95% CI 1.20-685.18, p=0.038) and 8.2 (95% CI 1.99-14.19, p=0.004) times, respectively. While hypertension, male and kidney disease have no significant increase of only 2.1 (95% CI 0.59-7.80, p=0.250), 1.8(95% CI 0.38-8.68, p=0.457) and 1.4 (95% CI 0.30-6.21, p=0.684) times, respectively.
(Table 2.)

Table 1 Characteristics of the study group.

Characteristics	Hearing loss (n=38)		No hearing loss (n=54)		P-value
	n	n%	n	n%	
Gender					
Male	32	84.2	42	77.8	
Female	6	15.8	12	22.2	0.444
Age (year)					
<60	20	52.6	25	46.3	0.549
≥60	18	47.4	29	53.7	
Alcohol drinking	24	63.2	29	56.9	0.549
Smoking	14	36.8	20	39.2	0.820
Diabetes	3	8.1	6	11.1	0.462*
Hypertension	15	40.5	13	24.1	0.075
Myocardial infarction	0	0	1	1.9	0.587*
Cerebrovascular event	3	7.9	3	5.6	0.483*
Anemia	14	37.8	25	47.2	0.379
Dyslipidemia	7	18.9	2	3.7	0.022*
Kidney disease	6	15.8	10	18.5	0.734
Meningitis	33	86.8	29	55.8	0.002

Table 2 Comparison of factors correlated to hearing loss with univariable and multivariable logistic regression presented Odds ratio, 95% CI and p-value.

Variables	Univariable			Multivariable		
	OR	95% CI	P-value	OR	95% CI	P-value
Male	1.5	0.46 - 5.48	0.595	1.8	0.38 - 8.68	0.457
Age ≥60 year	0.8	0.31 - 1.93	0.672	0.9	0.26 - 2.79	0.793
Alcohol drinking	1.3	0.51 - 3.38	0.663	0.9	0.25 - 3.30	0.891
Smoking	0.9	0.35 - 2.34	1.000	0.9	0.24 - 2.97	0.798
Diabetes	0.7	0.11 - 3.60	0.734	0.3	0.02 - 4.59	0.414
Hypertension	2.6	0.79 - 5.87	0.110	2.1	0.59 - 7.80	0.250
Cerebrovascular event	1.5	0.18 - 11.47	0.688	0.6	0.05 - 5.81	0.627
Anemia	0.7	0.26 - 1.74	0.390	0.8	0.26 - 2.58	0.740
Dyslipidemia	6.1	1.04 - 62.26	0.028	28.7	1.20 - 685.18	0.038
Kidney disease	0.8	0.22 - 2.82	0.787	1.4	0.30 - 6.21	0.684
Meningitis	5.2	1.63 - 19.58	0.002	8.2	1.99 - 34.19	0.004

Streptococcus suis is a Gram-positive cocci bacteria commonly found in tonsils and nasal cavities especially in piglets aged between 4–10 weeks (Dutkiewicz et al., 2017). This pathogen can be transmitted to humans mainly through pig exposure including raw pork consumption (Rayanakorn, Katip, Lee, & Oberdorfer, 2019). Currently, it has been reported that there are 1600 *Streptococcus suis* infection patients Worldwide. *Streptococcus suis* infection has been ranked the third place of adult's bacterial meningitis in

Thailand, after *Streptococcus pneumonia* and *Streptococcus agalactiae*, respectively (Opartpunyasarn, & Suwanpimolkul, 2019; Lin et al., 2019). Owing to raw pork consumption which is one of Thailand's traditional delicacies, the numbers of infected patients have significantly risen (Takeuchi et al., 2017). Common clinical manifestations are meningitis, arthritis, endocarditis, and endophthalmitis (Dutkiewicz et al., 2017), including general signs, for instance, acute fever, hypotension, shock and multiple organ dysfunction (Lin et al., 2019). Furthermore, common long-term sequelae of meningitis are hearing loss (53%) (Van Samkar et al., 2015) which is irreversible (Seele et al., 2018).

In this study, we evaluated the factors that increase the risk of hearing loss in patients with *Streptococcus suis* infection by Retrospective case-control study and the data were collected from medical records of infected patients with *Streptococcus suis* who were first diagnosed at Uttaradit hospital from 1 January 2009 to 31 October 2019. The factors are (1) gender, (2) age, (3) alcohol drinking, (4) smoking, (5) diabetes mellitus, (6) hypertension, (7) cerebrovascular events, (8) anemia, (9) dyslipidemia, (10) meningitis and (11) kidney disease. From an univariable logistic regression analysis study, The factors that increase the risk are dyslipidemia, meningitis, hypertension, male, cerebrovascular events and alcohol drinking but these factors could occur at the same time, so we use multivariable logistic regression analysis study. It is found that cerebrovascular events and alcohol drinking are protective factors while others can increase the risk. Dyslipidemia and meningitis can significantly increase the risk which related to previous study that (1) dyslipidemia and another metabolic syndrome such as diabetes mellitus and hypertension can cause microvasculopathy which leads to inner ear ischemia and hearing loss (Zhang et al., 2019). (2) Hearing loss from meningitis is caused by inflammatory process which releases cytokines that destroy blood-brain barrier so the pathogen can enter to subarachnoid space. It travels to the inner ear through cochlear aqueduct and perilymph (Takeuchi et al., 2017). (3) The research of Im et al., (2018) shown the incidences of hearing loss in male are significantly higher than female (GinJung Im.; 2018). (4) Kidney disease caused electrolyte imbalance, vitamin D deficiency and hyperuricemia which are pathologic to cochlea (Meena et al., 2012).

From the results, diabetes mellitus, cerebrovascular events, anemia, aging, alcohol drinking and smoking are protective factors that are not related to previous studies.
(1) Diabetes mellitus can also cause microvasculopathy as another metabolic syndrome (Zhang et al., 2019). (2) Cerebrovascular events are pathologic to auditory organs and cortex of the brain which can cause hearing loss (Koohi et al., 2019). (3) Anemia caused hearing loss by hypoxemia of labyrinthine artery (Mohammed et al., 2019). (4) Aging caused degenerative of cochlea by decreasing of sensory hair cells, spiral ganglion cells and degenerative of stria vascularis of the cochlear lateral wall of scala media (Frisina et al., 2016). (5) Smoking and alcohol drinking can cause endothelial cell injury, ischemic of cochlear and hearing loss (Dawes et al., 2012; Nakamura et al., 2001).

Having mentioned all of this, it demonstrated that some results in this study are not related to previous studies. A retrospective case-control study may possibly be one of the reasons because of the inaccuracy and incomplete data. Moreover, *Streptococcus suis* infection is a rare disease that there might not be an adequate sample size. Therefore, this study could not be represented for all *Streptococcus suis* infection patients but could be only used in Uttaradit hospital. Using this study on the conclusion of factors contributing to hearing loss in general patients might not be appropriated. For further study, we recommend a prospective study which we have the capability to control variables and adequate sample size.

5. Conclusion

This study indicated that the patients with *Streptococcus suis* infection and dyslipidemia or meningitis have an increased risk of hearing loss. Therefore, the surveillance of these patients is strongly recommended in order to decrease the incidence of hearing loss.

6. Acknowledgments

We would like to express our gratitude Assist. Prof. Jirawan Deeluea, Ph.D. Faculty of Nursing, Chiang Mai University and 5 of the fourth-year medical students, Uttaradit Medical Education Center.

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