# Intratracheal pressure related to objective voice quality, self-reported voice handicap and voice intensity of tracheoesophageal speakers

## A pilot study

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Master Thesis MA Speech-Language Pathology

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**Preface**

Before you lies the Master thesis "Intratracheal pressure related to objective voice quality, self-reported voice handicap and voice intensity of tracheoesophageal speakers: a pilot study", which forms the last research project of my Speech-Language Pathology Master's programme. I have written this thesis in the period between February and July 2022.

From a list of over thirty subjects, my preference went out to the research topic that was proposed by the Antoni van Leeuwenhoek hospital in Amsterdam. Speaking after a total laryngectomy did not receive much attention in my Master's programme, but did interest me from the start. Furthermore, I was more than interested in the practicalities of Speech-Language Pathology. It should be no surprise that I was very delighted when this subject was assigned to me. From the start of this project, I threw myself into everything that could increase my understanding of tracheoesophageal speech. Gaining knowledge about a topic I knew very little about was the challenge I was looking for.

I owe the creation of this text to several people who deserve to be mentioned here. First of all, I would like to thank Marise Neijman and Rob van Son for the expert supervision. You were always there to answer my questions and provide guidance when I got stuck in this project. Besides that, I would like to thank you and my fellow students, Mirjam and Demi, for the useful feedback and pleasant atmosphere during the meetings we had. A special thank for Marise for taking me to patient visits that I found very interesting and enlightening. I truly enjoyed experiencing a day in the life of a researcher in the hospital. I would like to thank Esther Janse for being the second reader of this thesis.

Finally yet importantly, I would like to thank my friends and family for the support, interest and motivational speeches. Thank you for listening to my enthusiastic stories, for the advice and for creating the peaceful place if necessary.

After more than five months of research, I am proud to present you this thesis. I hope you enjoy your reading.

Hidde van Gestel

Nijmegen, July 5, 2022

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## ABSTRACT

Tracheoesophageal (TE) speech is the golden standard if it comes to voice rehabilitation after a total laryngectomy (TL). This Master thesis provides a first investigation of intratracheal pressure that TE speakers need in order to speak, using a digital manometer. Ten TE speakers ($M_{age}$ = 68.2 years) were asked to read aloud voiced sentences and produce sustained vowels, both at comfortable as at extreme pitch and intensity levels. Spontaneous speech was elicited as well. A digital manometer registered intratracheal pressure in millimetres of mercury (mmHg). In addition, the Acoustic Voice Quality Index (AVQI) and Voice Handicap Index (VHI-10) were calculated in order to make connections between intratracheal pressure, objective voice quality and self-reported voice handicap. Lastly, voice intensity was analysed. Results pointed out that a digital manometer is a reliable tool for measuring intratracheal pressures. Furthermore, intratracheal pressures were higher for reading aloud sentences (*M* = 31.38 mmHg) and producing a comfortable sustained vowel (*M* = 31.07 mmHg) than for speaking spontaneously (*M* = 24.92 mmHg). Compared to the comfortable sustained vowel, extreme pitch levels did not alter the intratracheal pressure level, whereas extreme intensity levels did. No statistically significant correlations were found between intratracheal pressure, AVQI and VHI-10. A trend can be observed in VHI-10 scores: TE speakers that had to produce more intratracheal pressure for an average or less extreme intensity level had generally higher VHI-10 scores. This reveals that a possible connection between intratracheal pressure and self-reported voice handicap could exist. Further research is needed in order to gain more insight in these topics.

# 1. INTRODUCTION

## 1.1 Total laryngectomy

A total laryngectomy (TL) is a medical procedure, whereby the entire larynx is removed surgically. The most important reason to perform TL is an advanced laryngeal or hypopharyngeal carcinoma that cannot be treated with or recurred after radiotherapy (Hilgers & Van As, 2008; Ceachir et al., 2014). Another reason for TL is an a-functional larynx. Together with the removal of the larynx, the trachea is disconnected from the pharynx, which means that the upper and lower airways are separated. After a restoration of the digestive tract, the ear, nose and throat (ENT) surgeon, or otolaryngologist, creates an opening in the base of the neck. After the operation, patients breathe through this opening, also known as the tracheostoma (Jongmans et al., 2010).

In the Netherlands, otolaryngologists perform approximately 150 TLs every year (Jongmans et al., 2010)[1]. The *Integraal Kankercentrum Nederland* (IKNL, translation: Netherlands Comprehensive Cancer Organisation) collects data about the incidence and prevalence of different types of cancer. In 2021[2], 3,174 people got a form of head and neck cancer (HNC). Laryngeal and hypopharyngeal cancer, the forms of HNC that could lead to TL, occurred 680 (21.4%) and 177 (5.6%) times, respectively. The IKNL states that the incidence of laryngeal cancer – which occurs between 650 and 700 times a year – has decreased in the last few years, since smoking has become less omnipresent (Integraal Kankercentrum Nederland, n.d.). The incidence of hypopharyngeal cancer is stable (Integraal Kankercentrum Nederland, n.d.). One could roughly say that in 2021, 17.5% of the people with laryngeal or hypopharyngeal cancer underwent a TL[3].

### 1.2 Voice rehabilitation

TL has multiple consequences resulting from the separation of the digestive and respiratory tract. As the upper (mouth, nose and throat) and lower (trachea and lungs) airways are disconnected, breathing through the nose becomes impossible, which hampers smelling (Hilgers & Van As, 1999). Perhaps one of the most drastic consequences of TL is the loss of natural voice (Van Sluis et al., 2018). The absence of the vocal cords simply makes it impossible to speak in the natural way. However, there are currently three methods for voice rehabilitation: oesophageal speech, electrolaryngeal speech and tracheoesophageal speech (see **Figure 1A, 1B** and **1C**, respectively).

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[1] An interesting fact is the decreasing amount of TLs that is performed yearly. Ackerstaff et al. (1990) report that in the Netherlands, 250 TLs are performed every year. Thus, in around 20 years of time, the incidence of TL has decreased with 100 cases a year.

[2] Note: These are preliminary data (Integraal Kankercentrum Nederland, n.d.). Moreover, these are the most recent data that could be provided by the IKNL (accessed on 5 July 2022).

[3] $150/(680+177) * 100\% \approx 17.5\%$

Oesophageal speech (OS) is a non-surgical speech rehabilitation method. The alaryngeal speaker inhales or injects air in the cervical oesophagus and expels this air in order to bring the pharyngoesophageal (PE) segment in vibration (Zenga et al., 2018). The PE segment separates the pharynx from the oesophagus (Searl & Reeves, 2014). Because the PE segment serves as the new voice source for laryngectomized people, it is also referred to as the neoglottis. The main advantage of OS is that no surgery is required. Furthermore, patients do not need a device or their hands in order to speak. It is thus a costless speech method. However, a significant amount of time and motivation are needed in order to obtain a reasonable oesophageal voice and even then it remains to be seen whether the patient will be able to talk with an oesophageal voice (Zenga et al., 2018). At most 67% of TL patients manage to attain successful oesophageal speech (Schaefer & Johns, 1982, as cited in Zenga et al., 2018, pp. 41).

A second non-surgical speech rehabilitation method is electrolaryngeal speech (ELS). For this type of speech, patients need an electrolarynx. This device is placed against the neck (or another vibration allowing part of the face) and produces sound-generating vibrations in the oral cavity or pharyngeal mucosa, which then are modified with the articulators (Zenga et al., 2018). There are several devices available and patient's anatomical factors and preferences determine which device will be used (Kaye et al., 2017). The main advantage of ELS is the relatively easy implementation of this speech method so that the patient need little training. In contrast, the use of an electrolarynx results in a very mechanic-sounding voice, which is the biggest disadvantage of this speech method (Kaye et al., 2017). Van Sluis et al. (2018) found in a systematic review that speaking with an electrolarynx was the least pleasant and comprehensible compared to other speech rehabilitation methods.

The third speech rehabilitation method is tracheoesophageal speech (TES). In order to produce a TE voice, surgery is required. The surgeon implants a voice prosthesis in a tracheoesophageal puncture between the trachea and the oesophagus (Brook & Goodman, 2020). This voice prosthesis is a one-way valve, which means that it transfers air in only one direction. When a patient breathes normally, the prosthesis is closed. When a patient wants to speak, he/she covers his/her tracheostoma and air from the lungs shunts through the voice prosthesis past the neoglottis, which causes the neoglottis to vibrate and generate sound (Arenaz-Búa et al., 2017).

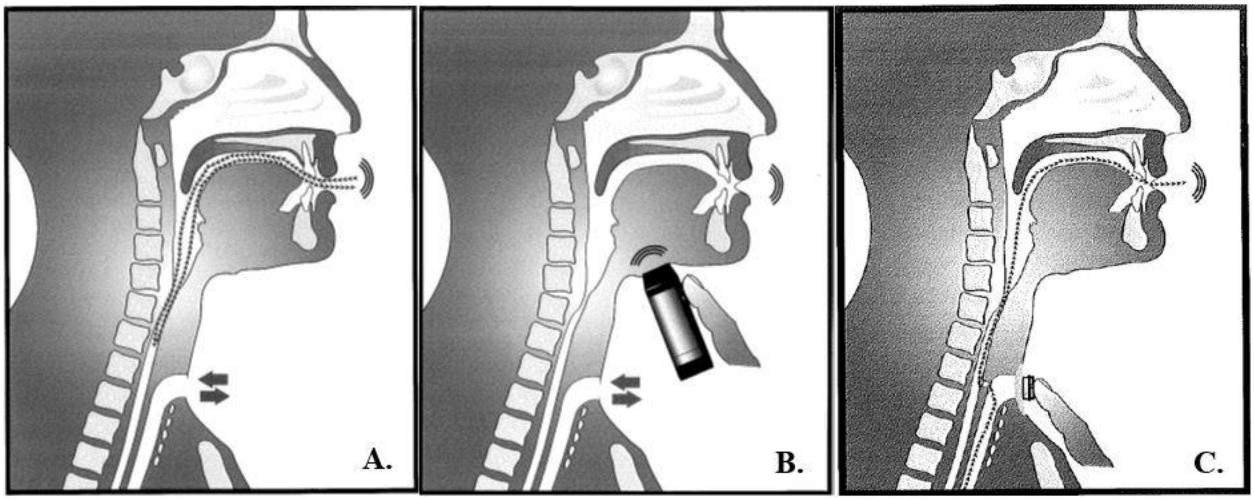


***Figure 1. A.*** Oesophageal speech; ***B.*** Electrolaryngeal speech; ***C.*** Tracheoesophageal speech. *Note.* Reprinted from "*Head and neck cancer: treatment, rehabilitation, and outcomes*", by Ward, E. C. and Van As-Brooks, C. J., 2014, p. 199, 214 and 231 respectively, Van Haren Publishing.

Thus, both OS and TES use the same voice source, viz the PE segment or neoglottis. To date, TES is the most common speech rehabilitation method in countries with Western medical practices (Searl & Reeves, 2014; Brook & Goodman, 2020). Malik et al. (2007) mention TES as the golden standard. The main disadvantage of TES is leakage through the prosthesis. This is unpleasant for the user and makes this rehabilitation method expensive.

Van Sluis et al. (2018) discussed the three speech rehabilitation methods in a systematic review and meta-analysis. The speech rehabilitation methods were compared to each other in terms of acoustic and perceptual outcomes and patients' self-reported appreciation of the new voice. The analyses showed that TES leads to better acoustic outcome values for $F_0$, maximum phonation time and vocal intensity compared to OS and EL. Furthermore, Van Sluis et al. (2018) found that in several studies, perceptual evaluations were better for TES. In other words, TE speakers have a voice that is of higher quality and more intelligible, according to both expert and naïve listeners. To conclude, Van Sluis et al. (2018) investigated whether the speaker groups (i.e. TES, OS and EL) rated their own voice differently and how they perceived their own vocal handicap. A comparison of the included studies showed that there was no clear trend. Thus, none of the speech rehabilitation methods led to higher or lower self-reported appreciation of patients. However, it looks like TES results in a voice that is of the best quality and highest intelligibility level.

### 1.3 Air pressure regulation

This thesis focuses on TES. One important change in TE voice production after TL is the air pressure regulation. In laryngeal speakers, vibrating vocal folds form the voice source. Air from the lungs passes the glottis, where the vocal folds start vibrating. These vibrations then travel through the vocal tract where they are modulated by several articulators (Zhang, 2016). The vocal folds are brought into vibration due to pressure differences in the subglottal and supraglottal system. After a TL, the entire larynx (including vocal folds) is removed. Therefore, a TE voice is produced differently. As stated earlier, air from the lungs is shunted into the oesophagus via a voice prosthesis and brings the PE segment in vibration (Arenaz-Búa et al., 2017). Thus, air from the lungs travels in another way to another voice source. This is associated with another way of regulating air pressure in the trachea, oesophagus and the mouth. This thesis investigates the pressure in the trachea that is needed to generate a TE voice. It builds on previous research on air pressure in TE speakers, which will be discussed in the next paragraphs.

#### 1.3.1 Intraoral pressure

Searl (2007) investigated intraoral pressure and labial contact pressure of TE speakers who produced bilabial consonants (/p/, /b/ and /m/) and compared this group to laryngeal speakers. Intraoral pressure was measured with a polyethylene tube that rested in a corner of the mouth and was connected to a transducer. Another transducer rested on the lower lip and detected the labial contact pressure. Participants read stimuli they saw on a computer screen. The results indicated that TE speakers had more intraoral pressure and exaggerated labial contact when producing consonant-vowel sequences and sentences with the target consonants. According to Searl (2007), this increased intraoral pressure and labial contact pressure can be seen as a compensatory mechanism to improve intelligibility. In another study, Searl (2020) showed that TE speakers experience increased talking effort. TE speakers felt increased effort in different body areas and factor analysis pointed out that there were two main categories: areas that were involved with voicing (voice/throat and lung/breathing) and areas that were not (articulators, mental/brain and arm/shoulder). For instance, the manual occlusion of the tracheostoma during talking could lead to an increased effort for the arm and shoulder (Searl, 2020). In both categories, TE speakers experience significantly more effort than laryngeal speakers, with large effect sizes (Searl, 2020). This increased effort was strongly correlated with different objective outcomes that describe articulatory effort, such as articulatory contact pressure. Searl & Knollhoff (2018) even found that some TE speakers talk less because of the increased effort. Thus, increased effort with the aim of speaking more intelligibly could be an explanation for the altered intraoral pressure. Another explanation is the change in aerodynamics due to the neoglottis, which is more resistant to airflow (Weinberg et al., 1982, as cited in Searl, 2007). That means that a TE speaker needs to build up more "subglottal" pressure in order to open the voice prosthesis and bring the neoglottis in vibration, contrary to a laryngeal speaker. The increased labial contact enables the higher pressure levels. The results concerning intraoral pressure are in line with previous results of Searl (2002). In this study, TE speakers and laryngeal speakers produced a wide range of consonant pairs (in terms of voicing) in a nonsense word (/mʌCə/, were 'C' represents the target consonant). Intraoral pressure was measured as in Searl (2007). The results suggest that TE speakers generate higher intraoral pressure compared to laryngeal speakers. Pressures were higher for voiceless consonants for all speakers and the Group × Voice interaction was significant as well, which means that TE speakers make more difference between voiced and voiceless consonants in terms of intraoral pressure. Two possible explanations are given: the production of voiceless consonants is either associated with more or less resistance of the neoglottis to airflow. Either the transglottal resistance has increased, which results in more subglottal and thus intraoral pressure, or the transglottal resistance has decreased, which results in more transmitted airflow and thus more intraoral pressure (Searl, 2002).

### 1.3.2 Intra-oesophageal pressure

Manometric measurements have been conducted to investigate oesophageal pressure during phonation. Takeshita et al. (2010) examined twelve TL patients in order to explore possible links between oesophageal pressure and voice quality. The participants performed several speech tasks (e.g. sustained vowel, spontaneous speech and singing "Happy birthday"). Based on this elicited speech samples, speech language pathologists (SLPs) gave a global rating of participants' voices. Pressure values were detected using high resolution manometry[4] with a digital manometer.

[4] When high resolution manometry is used, the manometer is inserted through the nose.

The results of the experiment indicated that poor speakers had higher oesophageal pressure during phonation than good speakers. In rest stages however, poor speakers had significantly lower oesophageal pressure. Takeshita et al. (2010) therefore suggest that the increase of pressure in poor speakers is a compensatory strategy, though it seems that increased difference between pressure in rest stages and during phonation is indicative for a low-quality TE voice. Takeshita et al. (2013) found similar results and thus confirmed Takeshita et al. (2010).

Following studies correlated oesophageal pressure outcomes with voice characteristics. Reis et al. (2013) investigated a potential correlation of oesophageal pressure with dynamic extension. Dynamic extension is the range of sound intensity levels a person can reach, i.e. the difference between the strongest and weakest phonation (Reis et al., 2013). Reis et al. (2013) measured intra-oesophageal pressures of 30 TE speakers during swallowing. A manometer with eight channels measured pressures during swallowing in the pharynx, proximal, middle and distal oesophagus. Afterwards, participants produced a sustained vowel /a/ in three intensity levels: strong, habitual and weak. TE speakers had an average dynamic extension of 18.98 dB NPS (*Range* = 4.7 – 35.5). Correlation analysis showed that oesophageal pressures in the proximal and distal parts during swallowing were significantly correlated with the dynamic extension. Correlations between dynamic extension and pressures in the other observed parts (pharynx and proximal oesophagus) reached the level of significance. This might suggest that intra-oesophageal pressure plays a role in the control of sound intensity levels of TE speakers (Reis et al., 2013). For unknown reasons, the authors divided the group in speakers with a ‘normal’ dynamic extension (>21 dB NPS) and speakers with an ‘altered’ dynamic extension (<21 dB NPS). Reis et al. (2013) are not clear about this separation and labeling. However, comparison of the groups indicated that TE speakers with a dynamic extension considered as 'altered' (<21 dB NPS) have a more abrupt decrease of intra-oesophageal pressure from distal oesophagus to proximal oesophagus. The pressure decrease of TE speakers with a 'normal' dynamic extension (>21 dB NPS) appeared to be more harmonious.

In following research, Takeshita-Monaretti et al. (2014) also correlated various objective speech outcomes with oesophageal pressure. Twenty TE speakers were asked to produce the vowel /a/ at maximum, habitual and minimum intensity level. They also produced the /a/ as long as they could several times. In this way, Takeshita-Monaretti et al. (2014) were able to collect data about maximum intensity, dynamic extension (e.g. the difference between minimum and maximum intensity level) and maximum phonation time. Pressure data were observed with a digital high resolution manometer while participants produced a sustained vowel /a/ at habitual intensity level. Results pointed out that pressure in the middle oesophagus correlated significantly with habitual and maximal intensity. There also was a significant correlation between pressure in the distal oesophagus and habitual intensity level. The entire intra-oesophageal pressure correlated significantly with the dynamic extension, which again highlights that intra-oesophageal pressure plays a role in vocal intensity regulation of TE speakers. With these findings, the suggestion of Reis et al. (2013) becomes more plausible. There were no significant correlations for intra-oesophageal pressures with maximum phonation time (Takeshita-Monaretti et al., 2014).

Arenaz-Búa et al. (2017) inspected the PE segment of TE speakers during rest, swallowing and phonation, using videofluoroscopic examination combined with high-resolution manometry (high resolution video manometry, HRVM). In this study, speech quality assessment of fourteen TE speakers was made by three SLPs. This was a perceptual assessment based on the Stockholm Voice Evaluation Approach and contained six variables: quality, intelligibility, hypo/hyper functional, breathy, rough and gurgly). Based on this variables, SLPs divided the TE speakers in good/reasonable (*n* = 11) and poor (*n* = 3) speakers. After the assessment, HRVM was conducted. Participants produced a sustained vowel (/ae/ or /e/) while they were being filmed with a special laryngoscope (HRES Endocam 5562.9 colour). Finally, a high resolution manometer was inserted through the nose to measure oesophageal pressure during swallowing. Relevant results of the experiment are visible in **Table 1** (Arenaz-Búa et al., 2017, p. 143). The HRVM outcomes indicate that good/reasonable TE speakers have lower pressure along the entire oesophagus during phonation and that the pressure decreases more gradually between the lower parts of the oesophagus to the upper parts. In contrast, HRVM detected higher pressures in the lower parts of the poor speakers' oesophagus. A striking finding is that pressures in the upper parts of poor

speakers' oesophagus is lower than those of good/reasonable speakers, which means that the pressure decrease along the oesophagus of poorer TE speakers is more abrupt. Arenaz-Búa et al. (2017) suggest that a harmoniously decreasing pressure gradient is required for a functional TE voice. Furthermore, the suggestion rises that there is a relation between swallowing and voice

***Table 1.*** Pressures (mmHg) in good/reasonable, poor speakers (as judged by perceptual analysis). Mean values ± SD, median in parentheses.

| | **Good/Reasonable N = 11** | **Poor N = 3** | **All Participants N = 14** |
|---|---|---|---|
| **During phonation** | | | |
| *Phonation 1* | 22 ± 11 (20) | 7 ± 2 (6) | 18 ± 11 (19) |
| *Phonation 2* | 39 ± 18 (34) | 39 ± 15 (41) | 39 ± 17 (37) |
| *Phonation 3* | 39 ± 20 (42) | 58 ± 31 (73) | 43 ± 23 (43) |
| *Phonation 4* | 54 ± 18 (42) | 68 ± 24 (88) | 57 ± 19 (59) |
| **During swallowing** | | | |
| *Pharyngeal pressure* | 77 ± 56 (54) | 133 ± 97 (48) | 89 ± 67 (68) |
| *Resting pressure* | 17 ± 9 (16) | 16 ± 11 (17) | 17 ± 9 (17) |
| *Oesophageal pressure* | 50 ± 31 (36) | 68 ± 50 (47) | 53 ± 34 (41) |

*Phonation 1 = phonation pressure 3 cm cranial to PES; Phonation 2 = pressure at PES; Phonation 3 = phonation pressure 3 cm caudal to PES; Phonation 4 = phonation pressure 7 cm cranial to lower oesophagus sphincter*

*Note*. Adapted from "The pharyngoesophageal segment after total laryngectomy", by B. Arenaz-Búa et al., 2017, *Annals of Otology, Rhinology & Laryngology*, *126*(2), 143. https://doi.org/10.1177/0003489416681321

quality, namely that good/reasonable speakers require less pressure during swallowing than poor speakers.[5]

Although previous discussed research suggests that a harmonious decrease of oesophageal pressure leads to a satisfactory TE voice (Takeshita et al., 2010; Takeshita et al., 2013; Reis et al., 2013; Takeshita-Monaretti et al., 2014; Arenaz-Búa et al., 2017), other research on pressure gradient of the PE segment seems to point in another direction. Zhang et al. (2016) and Zhang et al. (2019) performed HRVM with TE speakers (14 and 15 participants, respectively) in order to

[5] Resting pressure in Table 1 contributes to the suggestion, because both speaker groups show approximately the same resting pressure, which means that the starting point for both groups is equal.

learn about pressures associated with the PES. In both studies, participants had to produce a sustained vowel /a/ and complete the Voice Symptom Scale (Impairment subscale, VoiSS-I). Using HRVM, pressure gradient (ΔP) was measured as the difference between pressure in the upper parts of the oesophagus and 2cm above the vibrating PES. Linear regression analyses pointed out that, in both studies, ΔP and VoiSS-I scores were correlated significantly. In other words, higher pressure gradients were associated with lower VoiSS-I scores (indicating less voice impairment by patients) (Zhang et al., 2016; Zhang et al., 2019). Zhang et al. (2019) ran more analyses and found that ΔP was positively correlated with intensity (dB), which means that speakers with a higher pressure gradient were able to generate louder sustained vowels. Therefore, Zhang et al. (2016) and Zhang et al. (2019) suggest that a high pressure gradient plays a role in producing a satisfactory TE voice. This does not necessarily contradict previous research discussed above. Indeed, Zhang et al. (2016) and Zhang et al. (2019) investigated pressure around the PE segment, whereas previous research took a closer look at pressure gradient in the entire oesophagus. How all these results are related, has not been investigated yet. It shows how much is still uncertain about pressure and the TE voice.

### 1.3.3 Intratracheal pressure in TES

Another, rather less investigated topic, is the intratracheal pressure that is associated with TE speech production. Relatively little research has focused on comprehension of pressure build-up in the trachea of TE speakers. Grolman et al. (2007) investigated aerodynamics of the TE voice. In this study, the airflow, endotracheal and endoesophageal pressure of seven TE speakers were measured. Patients produced a sustained /a/ at comfortable, maximal and minimal intensity level. Endotracheal pressure was measured via the tracheostoma and endoesophageal pressure was measured with a Mikrotip transducer that was inserted through the nose and positioned at the level of the voice prosthesis. Elicited speech and airflow were captured with a facemask that covered the nose and mouth. The results showed that intensity level increased as pressure drop decreased (Grolman et al., 2007), i.e. when less pressure was lost between the trachea and oesophagus, participants were able to talk louder. Furthermore, findings indicated that sound intensity level increased when trans-source airflow, i.e. the airflow observed in the entire phonatory tract, increased. The results are summarized in **Table 2** (Grolman et al., 2007, p. 72).

***Table 2.*** Average pressure values (*SD*) for minimum, comfortable and maximum phonation during manual occlusion.

| **Phonation task** | **Endotracheal pressure (cm $H_2O$)** | **Endoesophageal pressure (cm $H_2O$)** | **Phonatory airflow (ml/s)** | **Sound pressure levels (dB SPL)** | **Pressure drop voice prosthesis (cm $H_2O$)** |
|---|---|---|---|---|---|
| **Minimum** | 27 (6.5) | 18 (7.8) | 133 (55) | 68 (6.4) | 9 (3.1), 33% |
| **Comfortable** | 33 (8.7) | 22 (9.5) | 167 (72) | 73 (5.6) | 11 (3.6), 33% |
| **Maximum** | 67 (7.3) | 52 (21) | 267 (122) | 81 (6.5) | 15 (4.5), 22% |

*Note*. Reprinted from "Aerodynamic and Sound Intensity Measurements in Tracheoesophageal Voice", by W. Grolman et al., 2007, *ORL*, *69*(2), 72. (https://dx.doi.org/10.1159/000097401)

Evangelista et al. (2021) were the first to measure intratracheal manometry pressures (IMPs), i.e. measuring intratracheal pressures using a manual manometer. Twenty-two patients that underwent TL and used TES participated in this study. A manometer was connected to their tracheostoma with a plaster. Patients were asked to produce a sustained /a/, answer an open-ended question to elicit conversational speech, and say "Hey" as loud as possible. Data of this study are presented in **Table 3** (Evangelista et al., 2021, p. 1069). Correlation analyses pointed out that IMPs in different speech tasks were correlated moderately to strongly with each other. They also showed that increased IMP led to decreased maximum phonation time, i.e. shorter maximum phonation time is related to higher IMP. Furthermore, Evangelista et al. (2021) investigated different IMP outcomes for TE speakers with different fluency levels. SLPs divided the TE speakers in two groups: fluent and non-fluent. The assessment criteria are not mentioned in Evangelista et al.'s (2021) article. The authors found that fluent TE speakers had decreased IMP. Speakers classified as non-fluent had significantly increased IMP, with large effect sizes. Evangelista et al. (2021) suggest that increased IMP can be seen as a compensatory mechanism: TE speakers build up more pressure in order to produce speech more easily. However, the increased IMP leads to poorer speech quality, which makes this compensatory mechanism counterproductive (Evangelista et al., 2021; cf. Takeshita et al., 2010).

As stated earlier, this thesis investigates the intratracheal pressure of TE speakers and therefore builds mainly on Evangelista et al.'s (2021) study. Intratracheal pressure will be related to an acoustic measurement and a score that gives information about a patient's self-reported experienced voice handicap. Both measurements will be discussed in the next section.

***Table 3.*** Intratracheal pressure values of TE speakers in different speech tasks.

| **Variable** | **Value** |
|---|---|
| Speech task, mean (SD) | |
| Sustained phonation, cm $H_2O$ | 50.5 (21.4) |
| Conversational speech, cm $H_2O$ | 52.3 (5.3) |
| Maximum | |
| Loudness, cm $H_2O$ | 92.05 (27.3) |
| Phonation time, s | 9.30 (5.3) |

*Note*. Adapted from "Association of Functional Outcomes in Tracheoesophageal Voicing With Intratracheal Pressures and Esophagram Findings", by L. Evangelista et al., 2021, *JAMA Otolaryngology–Head & Neck Surgery*, *147*(12), 1069. (https://doi.org/10.1001/jamaoto.2021.2409).

### 1.4 Measurements: VHI and AVQI

Jacobson et al. (1997) developed and validated the Voice Handicap Index (VHI) as a tool for measuring the psychosocial effects of voice disorders. Patients answer questions related to physical, emotional and functional aspects of their voice. A high VHI score indicates a strong experienced effect of the damaged voice (Jacobson et al., 1997). In 2004, Rosen et al. created a shorter version of the VHI, the VHI-10, which covers all three domains of the original VHI questionnaire with 10 items. The VHI-10 appeared to be a representative shortened variant of the VHI (Rosen et al., 2004). Over time, the VHI has been tested with alaryngeal speakers. Moerman et al. (2004) found out that the VHI is an adequate tool for evaluating self-reported handicap in the context of alaryngeal voices, as outcomes of 45 TL patients were distributed broadly and were not concentrated on a particular severity level. Lündstrom & Hammarberg (2011) investigated possible correlations between VHI-10 outcomes and perceptual and acoustic voice analyses. Therefore, 35 TE speakers were recorded. SLPs rated each speaker and acoustic analyses were performed. Patients completed the VHI-10. Correlation analyses pointed out that there were only a few correlations between VHI-10 outcomes and acoustic values that reached the level of significance. No significant correlation were found between VHI-10 outcomes and perceptual evaluations. The correlations indicated that patients' appreciation of their own voice was affected by other aspects than SLPs' judgement. Patients seem to rely on temporal aspects of voice, such as phrase length and pause time. There was also a significant correlation of VHI-score and voice intensity. Miyoshi et al. (2016) obtained similar results about VHI-10 and voice intensity level. Eadie et al. (2016) found a negative correlation between VHI-10 scores and scores on a questionnaire about communicative participation (Communicative Participation Item Bank, CPIB). In other words, alaryngeal speakers who are more affected by their new voice (and thus have a higher VHI-10 score), tend to take part in communicative daily life to a lesser extent (and thus have a lower CPIB score; Eadie et al., 2016). Klein-Rodríguez et al. (2020) related VHI-10 scores to acoustic values and found that VHI-scores were positively correlated to the frequency (in Hz) of the second formant (F2) for a sustained vowel /a/ and to the F1 frequency for a sustained /i/. Another interesting finding is that VHI-10 scores did not correlate with scores on a perceptual analysis (GRABS). That means that a patient's perception of the own voice is not related to the perception of a professional rater, for example an SLP (Klein-Rodríguez et al., 2020). However, as VHI-10 measures psychosocial domains and perceptual analyses of SLPs mainly focus on objective voice quality, it seems to make sense that both measurements do not necessarily have to correlate strongly. Part of the current study focuses on patients' appreciation of the own voice and experienced effort in speaking, so VHI-10 will be an important source of information.

The objective counterpart that will be used in this thesis is the Acoustic Voice Quality Index (AVQI). Maryn et al. (2010a) developed this objective measurement tool to tackle ecological validity issues with other objective tools for voice quality assessment that only use samples of sustained vowels. The AVQI is unique in that it uses both sustained vowels and samples of continuous speech. In short, the AVQI is a score based on six acoustic variables with cepstral peak prominence as main predictor for overall voice quality (Maryn et al., 2010a). The AVQI correlates strongly with perceptual judgements of SLPs and also the ability of the model to distinguish dysphonic from normophonic voices has been proven (Maryn et al., 2010a; Maryn et al., 2010b). Moreover, the AVQI seems to be sensitive to changes that are related to intervention. Therefore, the AVQI is a reliable tool for assessing the disturbed voice, a category the alaryngeal voice belongs to. Unfortunately, the AVQI is not validated for TE speakers but still will be used due to lack of an alternative. Moreover, Van Sluis et al. (2021) showed that the AVQI is sensitive to change in the post-TL voice. In their study, AVQIs were calculated at three, six and twelve months post-TL. The AVQI had decreased at six months post-TL. It seems possible that the AVQI is thus a useful tool for assessing the alaryngeal voice.

### 1.5 The current study

Evangelista et al. (2021) took the first step towards comprehension of intratracheal pressure levels of TE speakers and found that a lower intratracheal pressure indicated a TE voice with a longer maximal phonation time and thus more fluent. However, that does not end this topic. There is still a lot unknown about the role of pressure in the trachea of TE speakers in voice production. Therefore, this thesis is an attempt to add new knowledge to this research field. In the current study, intratracheal pressure of voicing TE speakers will be further investigated. Pressure levels in several speech conditions will be related to multiple values that represent acoustic voice outcomes and patients' self-reported voice quality and perceived handicap. In this way, the three aims of this thesis will be reached. Firstly, correlations between intratracheal pressure and acoustic/self-reported outcomes can be calculated. Secondly, the usability of pressure assessment as a voice quality predictor is checked. Thirdly, attention will be paid to the relation between voice intensity and intratracheal pressure in order to make possible connections to previous research addressing voice intensity and pressure gradient in the oesophagus (Reis et al., 2013; Takeshita-Monaretti et al., 2014). The main research question of this thesis is: Is there a relation between intratracheal pressures of TE speakers, objective and self-reported voice quality outcomes and voice intensity? Several sub-questions are asked in order to answer the main question:

- Which patterns in intratracheal pressure can be observed in TE speakers for different speaking condititions?
- What is the correlation between intratracheal pressure and an objective voice quality measurement (AVQI)?
- What is the correlation between intratracheal pressure and the patient's self-reported experienced handicap (VHI-10)?
- How does intratracheal pressure relate to voice intensity?

It is hypothesized that TE speakers with a voice of higher quality will show a lower intratracheal pressure level during speaking (cf. Evangelista et al., 2021). A lower intratracheal pressure level will then be associated with a lower AVQI, representing a higher voice quality (Maryn et al., 2010a). Although the AVQI is based on the laryngeal voice, it can be expected that TE speakers with a better voice quality will obtain a lower AVQI score. However, it is not known how big differences between TE speakers with different voice qualities will be. Patients with a higher pressure level during speaking, and thus a lower voice quality, will probably report a handicap that is more present, resulting in a higher VHI-10 score. Studies on the relation between intratracheal pressure and voice intensity are non-existent and thus, making any predictions about this part of the research is difficult. On the one hand, it could be expected that there will be a positive correlation between intensity levels (minimal, habitual, maximal and dynamic extension) and the intratracheal pressure. However, the positive correlations found in Reis et al. (2013) and Takeshita-Monaretti et al. (2014) are based on the oesophagus and there, high pressure is needed in order to prevent the airflow from leaking in the stomach. On the other hand, higher pressures could cause hypertonicity, which leads to lower voice quality, and maybe less control over the voice intensity. This study will give more clarification on the relation between intratracheal pressure and voice intensity.

## 2. METHODS

This study took place in the Antoni van Leeuwenhoek hospital/the Netherlands Cancer Institute in Amsterdam and is part of the SEATTLE study (N21STL), that was approved by the Medical Ethical Committee of the Antoni van Leeuwenhoek hospital (Protocol no. NL78528.031.21).

### 2.1 Participants

Ten patients (eight men and two women, mean age 68.2 years (*SD* = 7.8 years)) that underwent a TL were included in this study. A call for participants was launched to the patient association for TL patients. Patients were included if their TL and (if so) post-operative (chemo-) radiotherapy were at least six months ago. Patients were excluded if the carcinoma was residual, recurrent and/or if patients received palliative care. Patients did not necessarily have to be treated in the Antoni van Leeuwenhoek hospital. Participant characteristics are summarised in **Table 4**.

### 2.2 Materials

Intratracheal pressures measurement was performed with a FLUKE VT650 Gas Flow Analyzer (GFA) (**Figure 2**). This device measures air pressure per second in different units. For this study, millimetres of mercury (mmHg) is chosen as this will be the measurement unit of other parts including high resolution manometry of the SEATTLE study (N21STL). In this way, future data can be compared with the present data. Air is supplied to the FLUKE by a tube that is connected to the plaster on the tracheostoma. A connector was designed and 3D-printed for this study (**Figure 3**, see **Appendix I** for the concept drawing). Fitting exactly on the tracheostoma adhesive housing (based on both old and new ATOS plasters), this connector makes it possible to send air from the trachea directly to the GFA. A patient places the connector on his/her plaster and talks by putting his/her finger at the front of the connector. During the experiment, patients were allowed to use their own HME filter, which was connected to the connector. Thus, speaking with the printed connector follows the same pattern of closing the tracheostoma in order to shunt the air through the voice prosthesis, with the presence of the connector as the only difference. However, the airflow is digitally registered by the GFA, which results in a summary of the air pressure in mmHg per second. Patients were being audio and video recorded during the experiment. Audio recordings were performed by a SONY ICD-AX412F recorder and videos were made with a SONY ZV-E10 camera placed on a ROLLEI Mini M1 tripod.


***Figure 2.*** FLUKE VT650 GFA

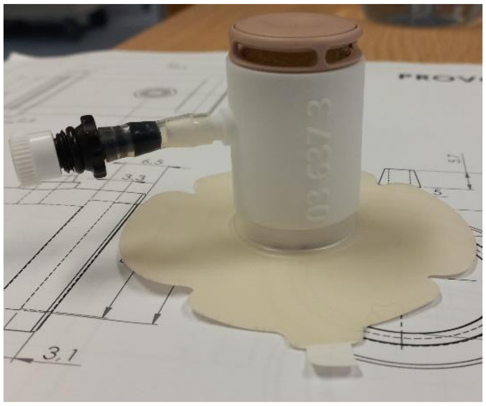

***Figure 3.*** 3D-printed connector.

*Table 4.* Participant characteristics.

| **Participant ID** | **Age** | **Gender** | **TL** | **Radiotherapy (no. + post/pre TL)** | **Voice prosthesis** | **HME filter** |
|---|---|---|---|---|---|---|
| STL1 | 61 | M | July 2016 | 35 post | Provox 2 | Handsfree |
| STL2 | 72 | F | December 2015 | 35 pre | Provox Vega 10mm XtraSeal | Provox Home |
| STL3 | 70 | M | January 2021 | 32 post | BlomSinger | Provox Go |
| STL4 | 78 | M | June 2018 | 35 pre | Provox Vega 10mm XtraSeal | Provox Life Protect |
| STL5 | 65 | M | March 2016 | 28 post | Activalve Light | Provox Home |
| STL6 | 73 | M | January 2019 | 35 pre | Provox Vega 10 mm | Provox Go |
| STL7 | 62 | F | July 2019 | 35 post | Provox Vega 8mm | Provox XtraFlow |
| STL8 | 53 | M | March 2021 | 35 post | Provox Vega 4mm | Laryvox Extra |
| STL9 | 72 | M | July 2014 | 35 post | Provox Vega 8mm | Provox XtraMoist |
| STL10 | 76 | M | June 2020 | 33 post | Provox Vega 6mm | Provox Home |

## 2.3 Procedure

Pressure measurements were performed between 15 April 2022 and 7 June 2022. When patients arrived at the hospital, they were briefed about the experiment. The experimenter introduced the GFA and explained what was going to happen. Patients were seated approximately 0.5 meter from the audio recorder and 1 meter from the video recorder. Whenever ready, the patient connected the connector to the plaster on his/her tracheostoma. With the GFA connected to their stoma, patients got two minutes of rest to get used to the device. After this, the experiment began. Three tasks were performed. The experimenter asked the patient to describe the route he/she took to come to the hospital. In this way, spontaneous speech was elicited. Furthermore, the patient had to read aloud three voiced sentences in Dutch.[6] The last task was to produce the sustained vowel /a/ in different extreme conditions. First, the patient had to produce /a/ as long as possible on a normal pitch and intensity. After that, the experimenter asked the patient to produce a sustained /a/ that was as quiet, as low, as high and as loud as possible. Patients were allowed to take a breath after every single task. The order of these tasks was not consistent. The task order for STL1, STL2 and STL3 was spontaneous speech, read aloud sentences, sustained vowels. The task order for the rest of the participants was spontaneous speech, sustained vowels, read aloud sentences. Afterwards, patients completed the VHI-10. Furthermore, patients indicated how much speaking in the experimental condition resembled speaking in daily life and whether the connector or GFA changed speaking. It should be noted that data from two types of measurement sessions are included in this thesis. Three out of ten sessions were trials that were done in order to make sure the connector and GFA worked. The remaining seven sessions were official T0-measurements for the SEATTLE study (N21STL). In the trial sessions, participants only performed the tasks as described above, whereas participants additionally were asked to read aloud a text and to produce a glowing tone (from low to high) in the T0-sessions. However, only data from the spontaneous speech, read aloud sentences and sustained vowels are being used in order to analyse as many uniform data as possible.

## 2.4 Pressure analysis

Pressure measured by the GFA was converted to an Excel file. One pressure value (in mmHg) for each second was registered by the GFA. Pressure was measured in the three different conditions that are described in the previous section. In order to make the data feasible, one pressure data point was calculated per patient per speech condition. For every condition, this means that multiple adjacent pressure values were averaged. Intratracheal pressure in the spontaneous speech condition was seen as the average of two adjacent pressure values during speech that was stable. As this thesis mainly investigates pressure that is needed in order to produce sound, only

[6] (i) 'Bebaarde mannen reizen naar warme landen.' ('Bearded men travel to warm countries.'); (ii) 'We waren er een jaar geleden.' ('We were there a year ago.'), and; (iii) 'Mama nam Nini mee naar Hengelo.' ('Mom took Nini to Hengelo (= a city in the Netherlands).').

pressure that was associated with the beginnings of sentences was observed. The stability of speech was observed in PRAAT version 6.2.09 (Boersma & Weenink, 2022). Speech was seen as stable if – for two seconds – the spectrogram showed no obvious changes, the intensity curve was not excessively descending or rising, and when the speech sounded steady. Two seconds of stable speech as observed in PRAAT matched with two pressure values that were averaged in order to obtain one data point for spontaneous speech per patient. Note that the two observed pressure values in all cases were also quite stable. For the reading aloud condition, intratracheal pressure values that were observed during the production of the entire sentence were averaged, as it usually take patients not more than three seconds to read aloud a sentence. Intratracheal pressure during sustained vowel production was seen as the average of two adjacent pressure values at the beginning of production of the vowel and when the voice was stable. Another reason for observing pressure values at the sound onset was the degree of consciousness of the task. For instance, when patients are asked to produce a sustained /a/ that is as low as possible, the first pressure values will show the pressure that is produced when patients try to do their best on performing the task.

The dynamic extension – the range between the most quiet and loudest a patient can speak – is also calculated. Voice intensity in decibel (dB) is averaged on the same data points intratracheal pressure values were based on.

**2.5 AVQI and VHI-10**

The Automatic Voice Quality Index (AVQI) was automatically calculated by a script (RunAVQI.praat) in PRAAT version 6.2.09 (Boersma & Weenink, 2022). In order to calculate the AVQI, three seconds of sustained vowel production and four seconds of continuous speech is required. The AVQI deals with regular speech and to this end, three seconds of the normal sustained /a/ were selected. In that condition, patients spoke on a comfortable level. The script calculates one value that represents the objective impression of the speech input. As said, this value runs from 0 to 10. The higher the AVQI, the poorer the voice quality.

After the experiment, patients completed the VHI-10 (see **Appendix II** for the Dutch version), which consisted of ten statements about the patients' perception of their own voice handicap. Patients rated every statement on a five-point scale (from 0 to 4). With these ratings, patients indicated to what extent the statements were applicable to their own situation, 0 meaning not applicable at all. The higher the VHI total score, the more a patient experience a voice handicap. Furthermore, patients were asked whether their voice sounded as usual or not. There were three possible answers: 'worse than usual', 'as usual', and 'better than usual'. Finally, patients marked a 100mm visual analogue scale (VAS) to judge the quality of their current voice; they put a vertical dash on a horizontal line running from 'no voice' on the far left to 'the best voice you can imagine' on the far right. The value presented in the Results section corresponds to the point where the patient's vertical dash crosses the horizontal line (in millimetres), counting from the far left ('no voice') as zero point.

### 2.6 Statistical analyses

In the Results section, a qualitative discussion of the pressure values will be provided. Due to the small sample size, performing inferential statistics produces results that are not very informative. Moreover, significance issues are very likely to occur. Therefore, descriptive statistics are performed. However, potential correlations between the AVQI, VHI and pressure results are calculated. Correlation analyses (Pearson's product-moment correlation) will be performed in R (R Core Team, 2021), using the `Hmisc` package (Harrell Jr, 2022). This package allows users to create a correlation matrix and calculates p-values at the same time. The level of significance was set to $\alpha = 0.05$. As stated earlier, the small sample size could lead to significance issues. The correlation values should therefore be seen as informative, but will not be a source for firm conclusions. In the Results section will only be spoken of trends and indications.

## 3. RESULTS

### 3.1 Intratracheal pressure in different speech conditions

Intratracheal pressure was measured in three speech conditions: spontaneous speech, reading-aloud voiced sentences and producing sustained vowels, both at a comfortable pitch and intensity level as in extreme conditions. Pressure data are summarized in **Table 5**. In **Appendix III**, intratracheal pressure values during the entire experiment of every participant are visible.

Average intratracheal pressure in the spontaneous speech condition was 24.92 mmHg (*SD* = 6.57 mmHg). The lowest and highest pressures measured in this condition were 16.26 mmHg and 37.76 mmHg, respectively. In order to read-aloud voiced sentences, participants produced on average a little more pressure (*M* = 31.38 mmHg; *SD* = 10.20 mmHg). The pressure levels ranged between 17.61 mmHg and 48.43 mmHg. Studying the intratracheal pressure values of the different sustained vowels, it is noticeable that the mean pressure values for the normal (*M* = 31.07 mmHg, *SD* = 11.32 mmHg), high (*M* = 31.26 mmHg, *SD* = 9.23 mmHg) and low (*M* = 32.01 mmHg, *SD* = 12.64 mmHg) sustained vowels are quite similar. The pressure levels in these three conditions were roughly equivalent (normal: 19.70 – 50.23 mmHg; high: 15.40 – 44.72 mmHg; low: 13.85 – 55.01 mmHg). When participants were instructed to produce an /a/ that was as quiet as possible, the intratracheal pressure was on average lower (*M* = 18.53 mmHg; *SD* = 9.80 mmHg) than for the normal /a/. Producing an /a/ that was as loud as possible rather made the intratracheal pressure increase to an average of 63.72 mmHg (*SD* = 16.87 mmHg). It is therefore not surprising that both the lowest and highest pressure levels are measured in the intensity conditions. The lowest intratracheal pressure measured was 6.88 mmHg for participant STL7 in the quiet condition. Participant STL5 produced the highest intratracheal pressure (99.37 mmHg) in the loud condition. More findings about pressure and intensity will be discussed later on in this section. Following findings will partly be based on the correlation matrix that can be found in **Table 6**. Due to the exploratory character of this pilot study, all possible correlations are calculated. Row 1–7 of **Table 6** show that most observed intratracheal pressure levels during all of the tasks performed by the participants correlate strongly with each other and that most of these correlations are statistically significant. Two extreme sustained vowel conditions, loud and low, form the exception.

***Table 5.*** Pressure levels (mmHg) per participant in different speech conditions.

| | **STL1** | **STL2** | **STL3** | **STL4** | **STL5** | **STL6** | **STL7** | **STL8** | **STL9** | **STL10** | **Mean (*SD*)** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Spontaneous** | 21.69 | 37.76 | 24.23 | 22.60 | 29.53 | 33.23 | 21.68 | 22.09 | 20.11 | 16.26 | 24.92 (6.57) |
| **Sentences** | 19.43 | 48.43 | 26.00 | 22.25 | 36.08 | 44.22 | 17.61 | 34.60 | 33.21 | 32.01 | 31.38 (10.20) |
| **Normal /a/** | 19.73 | 50.23 | 23.09 | 34.80 | 43.85 | 43.32 | 27.26 | 19.70 | 20.35 | 28.34 | 31.07 (11.32) |
| **Quiet /a/** | 10.18 | 38.63 | 28.39 | 16.87 | 18.59 | 26.24 | 6.88 | 10.78 | 14.83 | 13.90 | 18.53 (9.80) |
| **Loud /a/** | 57.93 | 70.32 | 40.41 | 53.68 | 99.37 | 80.52 | 55.24 | 49.31 | 64.30 | 66.13 | 63.72 (16.87) |
| **Low /a/** | 19.57 | 44.16 | 22.05 | 37.40 | 55.01 | 40.77 | 31.79 | 13.85 | 23.56 | 31.89 | 32.01 (12.64) |
| **High /a/** | 31.71 | 44.72 | 27.88 | 32.92 | 42.15 | 37.86 | 15.40 | 19.44 | 33.01 | 27.50 | 31.26 (9.23) |

### 3.2 AVQI and VHI-10

The Automatic Voice Quality Index (AVQI) was calculated for each participant. **Figure 4** shows an example of the output given by PRAAT after running the AVQI script. AVQI output per participant can be found in **Appendix IV**. An AVQI of 2.95 or higher indicates that the voice is most likely to be dysphonic (Maryn et al., 2010a,b). The mean AVQI was 8.47 (*SD* = 1.36). Eight out of ten AVQIs ranged between 8.5 and 9.0. The variance is very low. There were two outliers, namely participant STL7 with an AVQI of 9.82, which represents a voice that is of very low quality, and participant STL8, who had a relatively low AVQI of 4.73, given this sample. However, considering Maryn et al.'s (2010a,b) cut-off score of 2.95, all participants have a dysphonic voice.

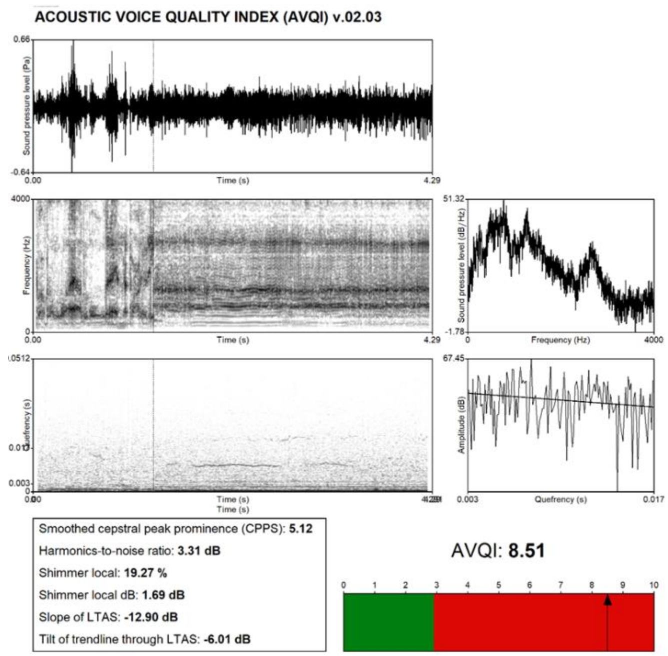


***Figure 4.*** Example of AVQI output (participant STL5).

**Appendix V** shows VHI-10 scores per participant. The mean VHI-10 score is 20.10 with a standard deviation of 4.84. The lowest VHI-10 score (12) was reported by participant STL1 and the highest (26) by participants STL2 and STL3. Participants voice rankings on the visual analogue scale (VAS) varied widely from 14 mm (participant STL4) to 91 mm (participant STL1). The mean VHI VAS score was 46.80 (*SD* = 23.97), which indicates that participants thought very differently about their voice quality on the moment of the experiment; some said it was the near-best voice they could imagine, whereas some stated they had nearly no voice at all, and some participants stood somewhere in the middle. When asked how participants found their voice on the particular moment of testing, eight out of ten said it was as usual, whereas two (STL3 and STL7) considered their voice better than usual.

***Table 6.*** Correlation matrix of overall pressure, AVQI, VHI-10 and intensity data.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1. Spontaneous** | – | | | | | | | | | | | | | |
| **2. Sentences** | .72* | – | | | | | | | | | | | | |
| **3. Normal /a/** | .84** | .66* | – | | | | | | | | | | | |
| **4. Quiet /a/** | .80** | .70* | .68* | – | | | | | | | | | | |
| **5. Loud /a/** | .49 | .55 | .69* | .20 | – | | | | | | | | | |
| **6. Low /a/** | .62 | .44 | .91** | .44 | .81** | – | | | | | | | | |
| **7. High /a/** | .70* | .64* | .74* | .70* | .67* | .68* | – | | | | | | | |
| **8. AVQI** | .12 | -.23 | .29 | .19 | .19 | .43 | .26 | – | | | | | | |
| **9. VHI-10 score** | .35 | .16 | .42 | .60 | -.30 | .24 | .03 | .20 | – | | | | | |
| **10. VHI-10 VAS** | -.06 | .02 | -.42 | -.09 | -.01 | -.44 | .16 | -.23 | -.71* | – | | | | |
| **11. Normal intensity** | .39 | .62 | .30 | .02 | .57 | .23 | .23 | -.55 | -.39 | .29 | – | | | |
| **12. Min. intensity** | .62 | .61 | .58 | .28 | .78** | .57 | .70* | -.22 | -.34 | .33 | .80** | – | | |
| **13. Max. intensity** | .13 | .36 | -.05 | -.20 | .43 | -.06 | .01 | -.24 | -.65* | .54 | .78** | .49 | – | |
| **14. Dyn. extension** | -.60 | -.43 | -.68* | -.47 | -.56 | -.68* | -.79** | .07 | -.09 | .02 | -.33 | -.77** | .19 | – |

* $p \leq .05$; ** $p \leq .01$

**Table 6** also shows the correlations between AVQI scores and VHI-10 outcomes. Neither strong nor statistically significant correlations can be found between these two measurement methods. Only the VHI-10 score and the VHI VAS score are correlating significantly ($r$ = -.71, $p \leq .05$).

### 3.3 Pressure and intensity

**Figure 5** shows a scatterplot of intratracheal pressure and voice intensity and indicates that the intensity level rises as the intratracheal pressure level increases. A Pearson's product-moment correlation test also reveals a statistically significant positive correlation ($r$ = .72, $p \leq .0001$). This is visible in the black line in **Figure 5**. However, when the three conditions quiet, normal and loud are being separated and plotted individually – which is also printed in **Figure 5** –, the correlation coefficients decrease and are no longer statistically significant. The correlation matrix in **Table 6** though shows some statistically significant correlations. First, the intratracheal pressure measured in the condition where participants had to produce a sustained /a/ on a comfortable pitch and intensity level correlates with the dynamic extension ($r$ = -.68, $p \leq .05$). In other words, a higher intratracheal pressure during the production of a normal sustained /a/ is associated with a lower dynamic extension. The correlations between the high and low pitched /a/'s and the dynamic extension are statistically significant, as well ($r$ = .-.79, $p \leq .01$ and $r$ = -.68, $p \leq .05$, respectively). Moreover, both the minimal and maximal intensity correlate statistically significantly with the normal intensity ($r$ = .80, $p \leq .01$ and $r$ = .78, $p \leq .01$, respectively). This shows that participants' intensity levels are consistent: if their voices are louder in

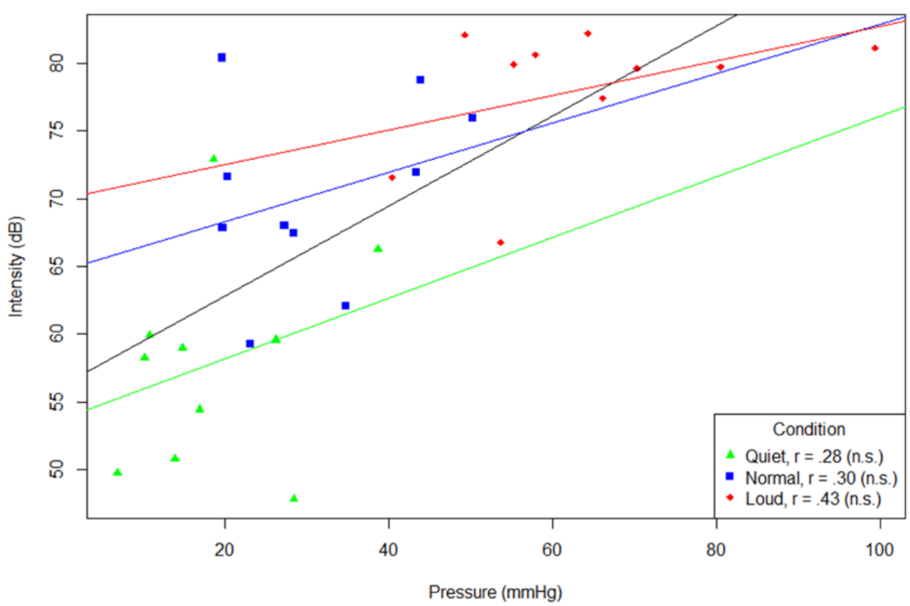


***Figure 5.*** Relation between intratracheal pressure and voice intensity level.

one condition, they tend to be louder in other conditions as well. Another statistically significant correlation is observed between the minimal intensity and the dynamic extension ($r$ = -.77, $p \leq .01$) and shows that the dynamic extension of participants of whom the quiet /a/ is louder, tends to be lower.

## 4. DISCUSSION

This thesis focused on the intratracheal pressure of post-TL patients who speak with a TE voice. In the previous section, all results were being discussed. In this section, the results will be placed in context, which will lead to the conclusions of this study. In addition, limitations and directions for prospective research will be presented.

### 4.1 General pressure results and measurement quality

In different tasks, intratracheal pressures were measured. It has been showed that spontaneous speech cost less pressure than reading-aloud voiced sentences. This could indicate that TE speakers put more effort in reading a sentence (or performing an imposed task instead of talking freely in general) and thus produce more pressure. The intratracheal pressure whilst producing a sustained vowel at comfortable pitch and intensity level nearly led to the same intratracheal pressure as for the sentences. Pressure values for the sustained vowels in extreme pitch conditions neither changed the intratracheal pressure; they remained around 31–32 mmHg. It thus looks like pitch changes do not affect the air pressure regulation. By contrast, the intensity extremities did change the intratracheal pressure. More on that topic will follow later on in this section.

Evangelista et al. (2021) were the first to perform almost the same examination, though they measured less conditions. Two important differences are the measurement unit and the measurement tool. Evangelista et al. (2021) used a manual manometer and registered intratracheal pressures in centimetres of water (cm $H_2O$), whereas a digital GFA registering in mmHg was being used in this study. **Table 7** shows the results of overlapping conditions in both studies next to each other. Although both Evangelista et al. (2021) use another measurement unit and measurement tool, it seems like the results roughly show the same pattern: the intratracheal pressure levels generated for producing spontaneous speech and a sustained vowel at comfortable pitch and intensity are quite similar. A small difference is observed: in this study, intratracheal pressure for comfortable sustained vowel production was slightly higher than for spontaneous speech production, whereas Evangelista et al. (2021) found it to be slightly lower. When a patient is asked to reach his/her intensity maximum, the intratracheal pressure strongly increases and (nearly) doubles compared to the other conditions. However, because of the methodological differences between the studies, it is hard to compare the results to a greater extent.

***Table 7.*** Overlapping data Evangelista et al. (2021) and current study.

| Condition | Evangelista et al. (2021), in cm $H_2O$ | The current study, in mmHg |
|---|---|---|
| **Spontaneous** | 52.30 | 24.92 |
| **Normal /a/** | 50.50 | 31.07 |
| **Loud /a/** | 92.05 | 63.72 |

A correlation analysis (**Table 6**) showed that the intratracheal pressure values for different tasks correlated strongly and statistically significant with each other. Spontaneous speech, reading aloud voiced sentences and producing a sustained vowel on a comfortable level correlated statistically significant. All extreme conditions for sustained vowel production correlated statistically significant with the comfortable sustained /a/. It therefore can be stated that the intratracheal pressure measurement using the FLUKE GFA is accurate. These results are similar to the results of Evangelista et al. (2021), who also found that the intratracheal pressure values in their different conditions correlated with each other. In particular for the purpose of feasibility this new finding is important. Measuring intratracheal pressures with a digital GFA will cost less effort and gives more consistent results. In the future, a digital GFA will probably be preferred over a manual manometer. Another important finding about the digital GFA itself is that participants did not report any substantial difference between talking whilst connected to the GFA and talking in daily life. The connector and GFA did not form an obstacle that disrupted speaking and it did not lead to a feeling of increased effort. Thus, it seems like the implementation of this measurement tool in investigating intratracheal pressures in TE speakers gives reliable results that correspond to a natural, non-experimental situation. Another important advantage is that this measurement method is non-invasive.

In the Introduction section of this thesis, studies about intra-oesophageal pressures have also been discussed broadly. How do these results relate to the results of the current study? In order to answer this question, pressure data has to be compared. Takeshita et al. (2010) measured pressures along the entire oesophagus and found that TE speakers had an average intra-oesophageal pressure of 32.61 (*SD* = 17.18) mmHg for the production of a sustained vowel at a comfortable pitch and intensity level. Takeshita et al. (2013), who nearly performed the same experiment as Takeshita et al. (2010), found approximately the same intra-oesphageal pressure level for a sustained vowel (*M* = 38.10 mmHg, *SD* = 21.53 mmHg). Takeshita-Monaretti et al. (2014) measured pressure levels along the entire oesophagus (distal, middle, proximal) and at the PE segment. The pressure level at the PE segment (*M* = 38.1 mmHg, *SD* = 21.5 mmHg) did approach the intratracheal pressure levels found in the current study (*M* = 31.07 mmHg, *SD* = 11.32 mmHg). The pressures in the distal (*M* = 53.6 mmHg, *SD* = 23.0 mmHg), middle (*M* = 49.3 mmHg, *SD* = 14.7 mmHg) and proximal (*M* = 43.3 mmHg, *SD* = 19.3 mmHg) oesophagus were on average a little higher than that. To conclude this summary of previous found data, Arenaz-Búa et al. (2017) measured pressures along the entire oesophagus and PE segment as well. They found that pressure at the PE segment was on average 39 mmHg (*SD* = 17 mmHg). Pressure beneath the PE segment was higher (up to 57 mmHg with a standard deviation of 19 mmHg) and lower above the PES (*M* = 18 mmHg, *SD* = 11 mmHg). Data from Arenaz-Búa et al.'s (2017) study is summarised in **Table 1** in the Introduction section. In summary, if intra-oesophageal pressure data was averaged along the entire oesophagus (Takeshita et al. 2010; Takeshita et al., 2013), they are a little bit higher than the intratracheal pressure found in this study. If the measurement location is specified (Takeshita-Monaretti et al., 2014; Arenaz-Búa et al., 2017), this also applies to the pressures found around the PE segment, which is then a little higher than the intratracheal pressure found in this study. Note that this comparison can only be made for sustained vowels at comfortable pitch and intensity level, as this is the only condition that is been measured in previous research on oesophageal pressure. It thus looks like the pressure that is been produced in the trachea of TE speakers increases a little when it enters the oesophagus. This could have multiple reasons. Grolman et al. (2007) found that airflow in the trachea and oesophagus of TE speakers was not different from that of laryngeal speakers, but the resistance of the PE segment was higher than the resistance of the vocal folds. This difference was statistically significant. The first possible explanation for an increased intra-oesophageal pressure is thus the resistance of the PE segment.

In order to vibrate the PE segment, the air that passed the voice prosthesis has to be pushed past it with high pressure. Therefore, pressure increases in the oesophagus. The other possible explanation is that a TE speaker avoids air leakage into the stomach (Takeshita-Monaretti et al., 2014). In that way, slightly lower intratracheal pressures indicate that the air has less possibilities to escape somewhere in the trachea; less pressure is required to make the air travel to the oesophagus. With the TE speaker covering his/her tracheostoma, the air in the trachea has no other choice than going to the oesophagus. Once there, the air could take multiple routes and the TE speaker has to stop it from leaking into the stomach. Therefore, higher pressure is found especially the lower parts of the oesophagus. However, these possible explanations are only based on the comparison with data of other studies. Future studies should investigate how air pressure (in mmHg) alters through the route from the trachea all the way to the upper oesophagus.

### 4.2 Pressure, objective voice quality and self-reported handicap

The next part of this thesis concerned possible relations of intratracheal pressure with an objective voice quality measure (the AVQI) and a score for self-reported handicap (the VHI-10 questionnaire). Both measurement tools failed to show statistically significant correlations with intratracheal pressure. First, the AVQI results are being discussed. Maryn et al. (2010a, 2010b) determined an AVQI cut-off score of 2.95, which means that scores that are higher than 2.95 are given to dysphonic voices. All of the participants scored far above 2.95, indicating that all voices were dysphonic. This is no surprise, because the AVQI is never validated for TE speakers (Hurren & Miller, 2017). As stated in the Results section, there was only little variance in AVQI scores: eight out of ten participants got a score that was between 8.5 and 9.0. There were two outliers. One participant got a score of 4.73 (STL8) and one participant had an AVQI of 9.82 (STL7). In this sample, the AVQI failed to show large differences in voice quality. This is remarkable, because at first glance it looked like there were larger differences between the speakers concerning voice quality. It should be noted, however, that the researcher is not experienced in rating TE voices and only judges based on auditory impression. The implementation of AVQI in TL research is novel. Previous research has found that there are reasons to consider the AVQI as a reliable tool for assessing TE voices, but that more research is needed to validate this tool (Barsties & De Bodt, 2015). Van Sluis et al. (2021) took speech samples three, six and twelve months post-TL and found out that the AVQI decreased over time, particularly between the third and sixth month post-TL. It therefore seems possible that the AVQI is sensitive for changes in the quality of the TE voice. By contrast, the current results show that the employability of the AVQI in TES research is not evident. Future research is needed to adjust the AVQI or develop a new measurement tool.

Secondly, VHI-10 results are discussed. These also indicate that all participants regard their own voice as abnormal. Arffa et al. (2012) propositioned a VHI-10 cut-off score of 11, which means that any score above 11 can be seen as abnormal. All ten participants crossed this border. A statistically significant negative correlation is found between the VHI-10 score and the place where participants marked the 100 mm VAS. This indicates that a higher score on the VHI-10 statements is associated with a ranking that is more on the left side of the VAS. This seems to make sense, since both a high VHI-10 score and a far left VAS ranking are associated with a poor voice quality and vice versa. However, no significant correlations were found with intratracheal pressure, which might indicate that this construct is not reflected in the VHI-10 scores. Patients perhaps do not consider air pressure when rating their own voice. Again, the main explanation is that the VHI-10 is not validated for alaryngeal speech. Moerman et al. (2004) developed a corrected VHI-10 score that considers TL-specific aspects. Van Sluis et al. (2021), however, showed that VHI-10 scores (not corrected in the manner of Moerman et al. (2004)) decreased over time, which means that TE speakers experience their voice fewer and fewer as a handicap: they learn how to live with it. Then again, the VHI-10 questionnaire looks like a reliable tool for measuring self-reported handicap of alaryngeal speakers. In Van Sluis et al.'s (2021) study, correlations between the AVQI and the VHI-10 were calculated. Their results give more clarification on how the AVQI could be used in the context of alaryngeal voices. Van Sluis et al. (2021) report no statistically significant correlation between the two measurement tools ($p$ = .017). However, their significance level was set to $\alpha$ = .01. It therefore is questionable whether the correlation is informative and could be used to draw any conclusions. When focusing on the post-TL time points, an AVQI of 6 correlated with a VHI-10 score of 11, which was the cut-off score for this tool (Arffa et al., 2012). Therefore, Van Sluis et al. (2021) suggest that –in the context of alaryngeal voices after TL– an AVQI cut-off score of 6 could be indicative for a VHI-10 score of 11, representing an unsatisfactory voice (pp. 1216). Again, this needs to be validated in future research.

## 4.3 Pressure and intensity

The fact that intratracheal pressure levels alter in the extreme intensity conditions suggests that there is a possible relation between pressure and intensity. On a macro-level, there seems to be a relation between pressure and intensity. In the Results section, it was visible that a lower pressure corresponded to a lower intensity level. However, when the three conditions (quiet, normal, loud) were torn apart, significant correlations were missing. Thus on a micro-level, there is no evidence for a relation between intratracheal pressure and intensity. Within the quiet condition, a lower pressure is not automatically associated with a lower intensity level and within the loud condition, the highest pressure level is not associated with the loudest phonation. In other words, although pressure levels alter within these conditions, this is not directly associated with changes in intensity. On average, a trend is visible: the pressure levels decrease in the quiet condition and increase in the loud condition. However, that does not translate into predictable or expected intensity levels within extreme intensity conditions.

In addition, correlation analysis showed that there was a statistically significant correlation between the intratracheal pressure for the comfortable sustained vowel and the dynamic extension. Higher pressure for an /a/ that was produced at comfortable pitch and intensity level was associated with a smaller dynamic extension. This correlation reveals a possible trend between intratracheal pressure and intensity control: participants that had to build up more intratracheal pressure for the production of a normal /a/ tend to make less difference between the quiet and loud condition, thus having less control over their voice intensity. Previous studies also investigated the relation between (oesophageal) pressure and intensity. It has been found that intra-oesophageal pressure correlates statistically significant with dynamic extension (Reis et al., 2013; Takeshita-Monaretti et al., 2014). The mean dynamic extension in the current study (20.24 dB) was higher than in previous studies (18.88 dB (Reis et al., 2013) and 12.3 dB (Takeshita-Monaretti et al., 2014)). The current study adds to the assumption that the intensity levels a TE speaker can reach is partly affected by intratracheal and intra-oesophageal pressure.

More correlations in the intensity spectrum (see **Table 6**, Row 12–14) substantiate the previous found trend. Both the minimal and maximal intensity correlated statistically significant with the normal intensity. This shows that participants' intensity levels are consistent: if their voices are louder in one condition, they tend to be louder in other conditions as well. A statistically significant correlation between the minimal intensity and the dynamic extension shows that the dynamic extension of participants of whom the quiet /a/ is louder, tends to be lower. This seems to make sense: after all, the louder a TE speaker's minimal intensity level, the louder his/her maximal intensity level has to be in order to obtain an average dynamic extension. However, this correlation shows that TE speakers with a louder minimal intensity level fail to compensate for this loudness at the maximal side, therefore having a smaller dynamic extension. Considering previous research, this could reveal that a small dynamic extension indeed indicates less control over voice intensity that is related to pressure. Future research should point out whether this applies to intratracheal pressure as well.

### 4.4 Voice control and self-reported handicap

Taking a glance at the VHI-10 results, some interesting remarks can be made when pressure data, intensity levels and VHI-10 scores per participant are examined. These data are printed in **Table 8**. Two font colours are used to give context to the data: green font means above the mean of the sample and red font means below the mean of the sample. When comparing participants with a VHI-10 score that is below the mean of the sample with the ones that have a higher VHI-10 score, it is notable that there are some similarities within these 'groups' in terms of intratracheal pressure and voice intensity. On the one hand, the participants with a below-mean VHI-10 score produce sustained vowels with a lower or around the average intratracheal pressure. The measured voice intensities, in turn, are more extreme or around the average. For instance, participant STL1

***Table 8.*** Intratracheal pressure (mmHg) and intensity levels (dB) per extreme-intensity sustained /a/ condition and VHI-10 score per participant.

| | **Pressure quiet (mmHg)** | **Min. intensity (dB)** | **Pressure loud (mmHg)** | **Max. intensity (dB)** | **Dynamic extension (dB)** | **VHI-10 score** |
|---|---|---|---|---|---|---|
| **STL1** | 10.18 | 58.23 | 57.93 | 80.59 | 22.36 | 12 |
| **STL2** | 38.63 | 66.25 | 70.32 | 79.59 | 13.35 | 26 |
| **STL3** | 28.39 | 47.82 | 40.41 | 71.55 | 23.74 | 26 |
| **STL4** | 16.87 | 54.43 | 53.68 | 66.79 | 12.36 | 25 |
| **STL5** | 18.59 | 72.88 | 99.37 | 81.14 | 8.26 | 16 |
| **STL6** | 26.24 | 59.57 | 80.52 | 79.71 | 20.14 | 21 |
| **STL7** | 6.88 | 49.75 | 55.24 | 79.91 | 30.16 | 22 |
| **STL8** | 10.78 | 59.94 | 49.31 | 82.08 | 22.14 | 18 |
| **STL9** | 14.83 | 58.97 | 64.30 | 82.20 | 23.23 | 15 |
| **STL10** | 13.90 | 50.77 | 66.13 | 77.40 | 26.63 | 20 |
| **Mean** | **18.53** | **57.86** | **63.72** | **78.10** | **20.24** | **20.1** |

***Note.*** Green font = above sample mean; red font = below sample mean obtains intensity levels that are around the average, but with intratracheal pressures that are somewhat lower than the sample mean. Participant STL10 produces a quiet sustained /a/ that is softer than the group mean with lower intratracheal pressure. One could say that participant STL10 performs 'better', as the task was to talk as quiet as possible. In the loud condition, STL10's performs around sample average. This first 'group' consists therefore of participants that obtain 'better' or average intratracheal pressures and intensity levels, which means their effort is not extremely great. Participants STL1, STL8, STL9 and STL10 belong to this group. On the other hand, there are participants that got a VHI-10 score that is above the mean of the sample. When observing their intratracheal pressures and voice intensity levels, it is striking that they perform more deviant from the sample mean, either by obtaining lower intensity levels (participant STL4) or by producing more intratracheal pressure for mean or higher intensity values (participant STL6 and STL2, respectively). It could be the case that the more effort a TE speaker has to put in a task, the higher his/her VHI-10 score will be. Participants STL3, STL5 and STL7, however, are hardly assignable to one of these groups. Participant STL3 produces a softer /a/ in the quiet condition with more intratracheal pressure and a softer /a/ in the louder condition with less intratracheal pressure. The dynamic extension is above sample mean, and yet STL3 has a high VHI-10 score. Participant STL5 has a VHI-10 score that is below sample mean, whereas the intensity levels, intratracheal pressure in the loud condition and the dynamic extension are 'worse'. Participant STL7 would fit in the first group, because of the low pressures and average intensity levels, but has an above sample mean VHI-10 score. These remarks could mean that VHI-10 score, and thus self-reported voice handicap, is reflected in the level of effort a TE speaker has to make in order to reach different intensity levels. When a speaker has to put more effort (i.e. higher pressure) in talking loudly with unsatisfactory effect, the TE speaker could possible regard his/her voice as a handicap to a greater extent. This should be investigated in the future.

### 4.5 Influence of medical decisions

This thesis was one of the first investigations of intratracheal pressure in TE speakers. The focus of this study were the consequences of different intratracheal pressure levels, i.e. how relates intratracheal pressure to differences in automatically assessed objective voice quality or self-reported handicap. The results showed that there were large interpersonal differences regarding intratracheal pressure but no statistically significant correlations between pressure, AVQI and VHI-10 were found. This thesis did not pay attention to possible causes for differences in intratracheal pressure. In this paragraph, this subject will be discussed shortly. It is possible that medical/surgical decisions influence the intratracheal pressure a TE speaker has to produce in order to speak. Schwarz et al. (2011) state that the surgical procedure of TL is not optimized concerning vibration characteristics of the PE segment (pp. 2768). It therefore could be the case that different surgical techniques could result in different resistancy levels of the PE segment, which in turn leads to the found differences in intratracheal pressure.

Another possibility is that the amount of post operative radiotherapy (PORT) influences pressure regulation. Gitomer et al. (2016) investigated the influence of radiation history on voice outcomes in TE speakers and found that radiation history had no substantial influence. However, radiotherapy can cause stricture formation in the oesophagus, or oesophageal stenosis (Sweeny et al., 2012). This could influence the vibrational function of the PE segment: more pressure is needed in order to bring the PE segment in vibration. This possibly might be a cause for different intratracheal pressure values. In **Table 4** in the Methods section, radiation history per participant is summarised. No clear differences can be observed in the amount of PORT patients received. Based on this data, no conclusions can be drawn about the possible influence of radiotherapy on intratracheal pressure.

To conclude this paragraph, the choice of voice prosthesis could affect intratracheal pressures. Each voice prosthesis has different characteristics that leads to differences in voice production. As can be seen in **Table 4** in the Methods section, most of the participants use a Provox® Vega voice prosthesis. Hancock et al. (2012) compared this prosthesis with the Blom-Singer Classic. Twenty-nine TE speakers were asked to compare both prostheses and fifteen of them (52%) preferred the Provox® Vega over the Blom-Singer Classic for speaking effort. One patient uses a Provox® 2, which has reduced airflow resistance compared to Blom-Singer prostheses (Kress et al., 2012). Because most of the patients use the same prosthesis, it is difficult to make any reliable comparisons. In this sample, no clear differences can be found. Future studies could compare intratracheal pressure levels associated with different voice prostheses. Also the influence of surgical procedures and radiotherapy could be investigated further.

## 4.6 Limitations

This study has possible limitations. The most prominent seems to be the small sample size of a mere ten participants. This study was conducted as part of the SEATTLE study (N21STL) that was still in its early stages, which means that participant selection was ongoing. In the period from April to June 2022 in which data for this thesis were collected, ten TE speakers were able to perform an intratracheal pressure measurement. Although correlations should be interpreted with caution, global trends could be observed in this exploration of the intratracheal pressure in TE speakers. Since a global investigation of intratracheal pressures was the main goal of this thesis, the small sample size does not pose a direct problem, but rather is a reason for further replication studies.

Another limitation of the study is the use of the AVQI as unsecure measurement tool. The AVQI has not been validated for alaryngeal speech yet. However, research of Van Sluis et al. (2021) showed that the AVQI could give useful results in this context. The disadvantage of using the AVQI as measurement tool is that any obtained results in this study would have been based on this unsecure tool. It therefore is questionable how useful results are. By contrast, using the AVQI in this study provided insight in the unsecurity of the tool and underlined the importance of a revision of the AVQI for alaryngeal speech.

The last possible limitation of this study is that it would have been more complete to include a perceptual assessment of the TE speakers. If voice evaluations of SLPs were included, this study would have brought a complete overview of the relations between intratracheal pressure and voice quality from all perspectives.

## 4.7 Future research

In future, research on intratracheal pressures of TE speakers should be continued. Including more participants could enable researchers to perform inferential statistics. Furthermore, it will be interesting to test various intervention methods for air pressure regulation and compare intratracheal pressure levels before and after these interventions. Differences in intratracheal pressure could then be related to objective, perceptual and self-reported voice quality. This should reveal how intervention techniques could improve voice quality and how these techniques will help the TE speakers. Perhaps the effort a speaker has to put in speaking will decrease when they would learn how to control their internal pressure regulation. Another proposition for future research is to investigate the influence of the mentioned medical decisions on the intratracheal pressure. Intratracheal pressure of patients with different reconstruction methods, voice prostheses and radiotherapy histories could be compared in order to investigate the influences on intratracheal pressure levels during speaking.

The SEATTLE study (NL21STL) that is performed at the Antoni van Leeuwenhoek hospital/the Netherlands Cancer Institute in Amsterdam will continue in the coming period with more participants ($n$ = 20). This will give more insight in not only speaking, but also swallowing problems that are experienced by TL patients. Inter alia, pressures during swallowing will be analysed. This could lead to interesting relations with speaking.

## 4.8 Conclusions

This thesis was a first investigation of intratracheal pressures of TE speakers, using a digital manometer or GFA. It has been found that this measurement device gives reliable values, as pressure levels in different speaking conditions correlate statistically significant with each other. This measurement method is time-saving compared to a manual manometer and involves less subjectivity of a registering researcher. Furthermore, all participants of this study stated that speaking during the experiment did not feel different compared to speaking in daily life. This measurement device thus measures natural speech. Another important advantage of the use of a GFA is that this is a non-invasive pressure measurement device. A first conclusion of this thesis is therefore that a GFA is a reliable tool for measuring intratracheal pressures of TE speakers.

Secondly, trends regarding intratracheal pressure are observed. Spontaneous speech involves less intratracheal pressure than performing an imposed task, such as reading aloud a voiced sentence or producing a sustained vowel. Concerning sustained vowel production, it seems that extreme pitch changes (talking as low or high as possible) do not require more or less intratracheal pressure level than the production of a comfortable pitch level, whereas extreme intensity changes do. Intratracheal pressure and intensity are related to each other: the louder a TE speaker wants to talk, the higher the produced intratracheal pressure is. Another striking finding is that a TE speaker is less able to voice very quiet when he/she already needs more intratracheal pressure to talk at comfortable level. Moreover, the dynamic extension is smaller when this is the case. This reveals that intratracheal pressure plays a role in the control over voice intensity.

Thirdly, relations between intratracheal pressure, objective voice quality and self-reported handicap are hard to find. The AVQI is an insecure measurement tool for assessing the voice quality of TE speakers, since it has never been validated for alaryngeal speech. Scores on the VHI-10 did not show significant correlations with intratracheal pressure levels. However, it is not known whether pressure is considered when TE speakers think about their voice as a handicap. Although significant correlations were not found, it was remarkable that patients who on average needed more intratracheal pressure and had a dynamic extension below sample mean had a higher VHI-10 score. In other words, putting more effort in a task but performing worse than the sample mean was reflected in a higher VHI-10 score, representating a self-reported voice handicap. In particular, voice intensity seems to show relations with intratracheal pressure and self-reported handicap. Future research should be conducted in order to investigate this possible relations, influence of different medical factors on intratracheal pressure and intervention effects.

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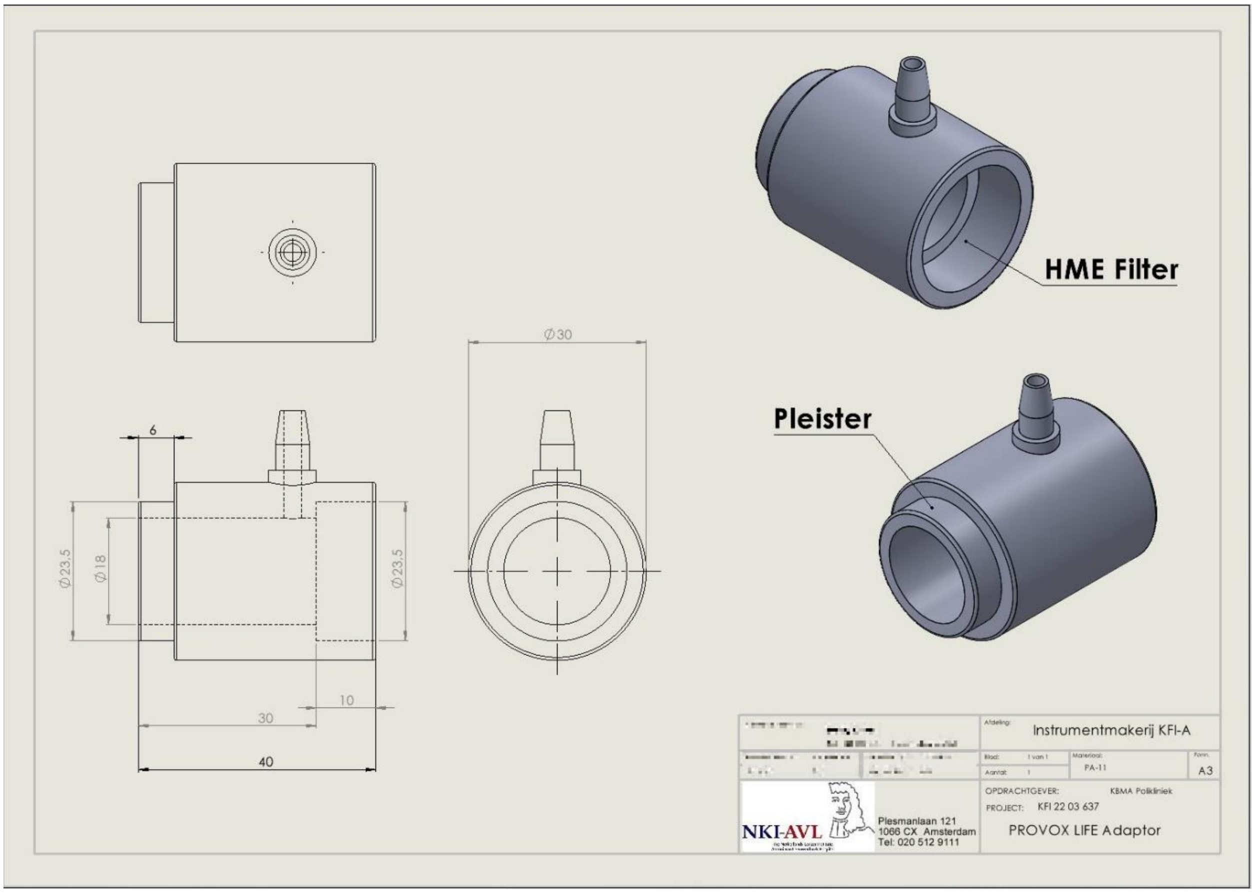
## Appendix I: concept drawing of connector



## Appendix II: VHI-10 questionnaire (in Dutch)

**VHI-10**
***Voice Handicap Index***

**Instructie**:

Dit zijn uitspraken die veel mensen gebruiken om hun stemkwaliteit, en het effect dat hun stem op hun dagelijks leven heeft, te beschrijven. Geef voor elke uitspraak aan hoe vaak u deze uitspraak zelf ervaart, door een kruisje te zetten.

0 = Nooit 1 = Bijna nooit 2 = Soms 3 = Bijna altijd 4 = Altijd

| | | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|
| 1. | Door mijn stem kan ik mij moeilijker verstaanbaar maken | | | | | |
| 2. | Mensen verstaan me moeilijk in een lawaaierige omgeving | | | | | |
| 3. | Men vraagt me: 'wat is er mis met uw stem?' | | | | | |
| 4. | Ik heb het gevoel mij te moeten inspannen om stem te geven | | | | | |
| 5. | Mijn stemproblemen beperken mijn persoonlijk en sociaal leven | | | | | |
| 6. | De helderheid van mijn stem is onvoorspelbaar | | | | | |
| 7. | Ik heb het gevoel dat ik buiten conversaties gehouden word omwille van mijn stem | | | | | |
| 8. | Mijn stemprobleem veroorzaakt een inkomensverlies | | | | | |
| 9. | Mijn stemprobleem ergert mij | | | | | |
| 10. | Ik voel mijn stemprobleem aan als een handicap | | | | | |

Hoe klinkt uw stem vandaag?

❑ zoals gewoonlijk ❑ slechter dan gewoonlijk ❑ beter dan gewoonlijk

***Oordeel huidige stemkwaliteit***

Geef met behulp van een verticale streep | op de lijn aan hoe u uw eigen stem op dit moment beoordeelt.

Geen stem ________________________________________ De beste stem die u zich kunt voorstellen

**Appendix III: Intratracheal pressure data per participant**

***STL1***

| FLUKE time | mmHg | Condition |
|---|---|---|
| 00:00:00 | 0.217 | rest |
| 00:00:01 | 0.139 | rest |
| 00:00:02 | -0.541 | rest |
| 00:00:03 | 0.715 | rest |
| 00:00:04 | -3.682 | rest |
| 00:00:05 | -0.405 | rest |
| 00:00:06 | 21.855 | spontaneous |
| 00:00:07 | 12.917 | spontaneous |
| 00:00:08 | 14.226 | spontaneous |
| 00:00:09 | 6.801 | spontaneous |
| 00:00:10 | 14.106 | spontaneous |
| 00:00:11 | -1.7 | spontaneous |
| 00:00:12 | 5.623 | spontaneous |
| 00:00:13 | -0.024 | spontaneous |
| 00:00:14 | 14.558 | spontaneous |
| 00:00:15 | 16.117 | spontaneous |
| 00:00:16 | 8.19 | spontaneous |
| 00:00:17 | 3.807 | spontaneous |
| 00:00:18 | 0.691 | rest |
| 00:00:19 | 0.115 | rest |
| 00:00:20 | 0.147 | rest |
| 00:00:21 | 20.713 | spontaneous |
| 00:00:22 | 22.67 | spontaneous |
| 00:00:23 | 17.851 | spontaneous |
| 00:00:24 | 0.329 | spontaneous |

| | | |
|---|---|---|
| 00:00:25 | 16.245 | spontaneous |
| 00:00:26 | 11.957 | spontaneous |
| 00:00:27 | 0.507 | rest |
| 00:00:28 | -0.097 | rest |
| 00:00:29 | 0.255 | rest |
| 00:00:30 | 0.269 | rest |
| 00:00:31 | -1.272 | rest |
| 00:00:32 | 0.244 | rest |
| 00:00:33 | -0.514 | rest |
| 00:00:34 | -1.716 | rest |
| 00:00:35 | 23.057 | sentence 1 |
| 00:00:36 | 18.071 | sentence 1 |
| 00:00:37 | 22.554 | sentence 1 |
| 00:00:38 | 4.233 | sentence 1 |
| 00:00:39 | -0.125 | rest |
| 00:00:40 | 0.188 | rest |
| 00:00:41 | 0.093 | rest |
| 00:00:42 | -0.439 | rest |
| 00:00:43 | 24.051 | sentence 2 |
| 00:00:44 | 20.76 | sentence 2 |
| 00:00:45 | 0.77 | sentence 2 |
| 00:00:46 | -0.305 | rest |
| 00:00:47 | -0.26 | rest |
| 00:00:48 | 0.117 | rest |
| 00:00:49 | 10.35 | sentence 3 |
| 00:00:50 | 20.285 | sentence 3 |
| 00:00:51 | 3.375 | sentence 3 |
| 00:00:52 | 0.288 | rest |
| 00:00:53 | 0.252 | rest |
| 00:00:54 | 0.431 | rest |

| | | |
|---|---|---|
| 00:00:55 | 0.214 | rest |
| 00:00:56 | 0.254 | rest |
| 00:00:57 | -2.342 | rest |
| 00:00:58 | -0.518 | rest |
| 00:00:59 | 1.152 | rest |
| 00:01:00 | 0.958 | rest |
| 00:01:01 | -0.181 | rest |
| 00:01:02 | 0.218 | rest |
| 00:01:03 | -3.15 | rest |
| 00:01:04 | 0.107 | rest |
| 00:01:05 | 21.335 | a comfortable |
| 00:01:06 | 18.115 | a comfortable |
| 00:01:07 | 18.362 | a comfortable |
| 00:01:08 | 19.032 | a comfortable |
| 00:01:09 | 9.323 | a comfortable |
| 00:01:10 | 4.762 | a comfortable |
| 00:01:11 | 0.116 | rest |
| 00:01:12 | -0.236 | rest |
| 00:01:13 | 0.223 | rest |
| 00:01:14 | -0.093 | rest |
| 00:01:15 | 0.26 | rest |
| 00:01:16 | 0.279 | rest |
| 00:01:17 | 0.219 | rest |
| 00:01:18 | -1.801 | rest |
| 00:01:19 | -0.741 | rest |
| 00:01:20 | -0.351 | rest |
| 00:01:21 | 10.743 | a quiet |
| 00:01:22 | 9.617 | a quiet |
| 00:01:23 | 8.702 | a quiet |
| 00:01:24 | 8.938 | a quiet |

| | | |
|---|---|---|
| 00:01:25 | 10.155 | a quiet |
| 00:01:26 | 11.156 | a quiet |
| 00:01:27 | 10.85 | a quiet |
| 00:01:28 | 7.666 | a quiet |
| 00:01:29 | 0.25 | a quiet |
| 00:01:30 | 0.245 | rest |
| 00:01:31 | 0.106 | rest |
| 00:01:32 | 0.283 | rest |
| 00:01:33 | -0.389 | rest |
| 00:01:34 | -1.475 | rest |
| 00:01:35 | 18.358 | a low |
| 00:01:36 | 20.785 | a low |
| 00:01:37 | 17.779 | a low |
| 00:01:38 | 15.156 | a low |
| 00:01:39 | 4.262 | a low |
| 00:01:40 | -0.06 | rest |
| 00:01:41 | 0.152 | rest |
| 00:01:42 | 0.2 | rest |
| 00:01:43 | -0.41 | rest |
| 00:01:44 | -2.76 | rest |
| 00:01:45 | 30.22 | a high |
| 00:01:46 | 33.193 | a high |
| 00:01:47 | 29.011 | a high |
| 00:01:48 | 15.103 | a high |
| 00:01:49 | 0.172 | rest |
| 00:01:50 | 0.152 | rest |
| 00:01:51 | 0.159 | rest |
| 00:01:52 | 0.167 | rest |
| 00:01:53 | -0.126 | rest |
| 00:01:54 | -0.692 | rest |

| | | |
|---|---|---|
| 00:01:55 | -0.666 | rest |
| 00:01:56 | 62.509 | a loud |
| 00:01:57 | 53.357 | a loud |
| 00:01:58 | 5.654 | a loud |
| 00:01:59 | 0.175 | rest |
| 00:02:00 | 0.187 | rest |

***STL2***

| **FLUKE time** | **mmHg** | **Condition** |
|---|---|---|
| 00:00:00 | -0.572 | rest |
| 00:00:01 | -0.272 | rest |
| 00:00:02 | 0.304 | rest |
| 00:00:03 | -1.284 | rest |
| 00:00:04 | 0.465 | rest |
| 00:00:05 | -0.016 | rest |
| 00:00:06 | 0.018 | rest |
| 00:00:07 | -0.973 | rest |
| 00:00:08 | -1.162 | rest |
| 00:00:09 | 38.595 | spontaneous |
| 00:00:10 | 46.652 | spontaneous |
| 00:00:11 | -0.853 | spontaneous |
| 00:00:12 | 49.036 | spontaneous |
| 00:00:13 | 39.02 | spontaneous |
| 00:00:14 | -1.984 | spontaneous |
| 00:00:15 | 45.947 | spontaneous |
| 00:00:16 | 13.639 | spontaneous |
| 00:00:17 | 51.943 | spontaneous |
| 00:00:18 | 30.293 | spontaneous |
| 00:00:19 | 0.339 | rest |

| | | |
|---|---|---|
| 00:00:20 | -0.044 | rest |
| 00:00:21 | -0.059 | rest |
| 00:00:22 | -3.064 | rest |
| 00:00:23 | 39.199 | spontaneous |
| 00:00:24 | 36.329 | spontaneous |
| 00:00:25 | 2.048 | spontaneous |
| 00:00:26 | 44.8 | spontaneous |
| 00:00:27 | 40.727 | spontaneous |
| 00:00:28 | -0.584 | spontaneous |
| 00:00:29 | -0.46 | spontaneous |
| 00:00:30 | 37.399 | spontaneous |
| 00:00:31 | 0.56 | spontaneous |
| 00:00:32 | 31.722 | spontaneous |
| 00:00:33 | 5.84 | spontaneous |
| 00:00:34 | -0.046 | rest |
| 00:00:35 | 0.13 | rest |
| 00:00:36 | 0.018 | rest |
| 00:00:37 | -0.025 | rest |
| 00:00:38 | -0.027 | rest |
| 00:00:39 | -0.018 | rest |
| 00:00:40 | -0.033 | rest |
| 00:00:41 | -0.125 | rest |
| 00:00:42 | 0.327 | rest |
| 00:00:43 | -2.826 | rest |
| 00:00:44 | 11.195 | sentence 1 |
| 00:00:45 | 57.139 | sentence 1 |
| 00:00:46 | 46.764 | sentence 1 |
| 00:00:47 | 48.132 | sentence 1 |
| 00:00:48 | 4.907 | sentence 1 |
| 00:00:49 | -0.549 | rest |

| | | |
|---|---|---|
| 00:00:50 | 9.245 | Try sentence 2 |
| 00:00:51 | 0.4 | rest |
| 00:00:52 | 0.179 | rest |
| 00:00:53 | 0 | rest |
| 00:00:54 | -1.654 | rest |
| 00:00:55 | 38.568 | sentence 2 |
| 00:00:56 | 50.885 | sentence 2 |
| 00:00:57 | 39.367 | sentence 2 |
| 00:00:58 | 13.861 | sentence 2 |
| 00:00:59 | -0.039 | rest |
| 00:01:00 | -1.408 | rest |
| 00:01:01 | 53.38 | sentence 3 |
| 00:01:02 | 43.827 | sentence 3 |
| 00:01:03 | 36.745 | sentence 3 |
| 00:01:04 | 11.615 | sentence 3 |
| 00:01:05 | -0.506 | rest |
| 00:01:06 | 0.029 | rest |
| 00:01:07 | -1.338 | rest |
| 00:01:08 | 8.617 | Try a |
| 00:01:09 | 0.435 | rest |
| 00:01:10 | -0.427 | rest |
| 00:01:11 | 0.156 | rest |
| 00:01:12 | 0.015 | rest |
| 00:01:13 | -0.76 | rest |
| 00:01:14 | -1.539 | rest |
| 00:01:15 | -1.294 | rest |
| 00:01:16 | 9.967 | a comfortable |
| 00:01:17 | 48.635 | a comfortable |
| 00:01:18 | 51.816 | a comfortable |
| 00:01:19 | 45.998 | a comfortable |

| | | |
|---|---|---|
| 00:01:20 | 46.242 | a comfortable |
| 00:01:21 | 46.939 | a comfortable |
| 00:01:22 | 44.633 | a comfortable |
| 00:01:23 | 38.338 | a comfortable |
| 00:01:24 | 4.386 | a comfortable |
| 00:01:25 | -0.251 | rest |
| 00:01:26 | -2.418 | rest |
| 00:01:27 | 0.817 | rest |
| 00:01:28 | 0.235 | rest |
| 00:01:29 | -0.404 | rest |
| 00:01:30 | 0.142 | rest |
| 00:01:31 | -0.01 | rest |
| 00:01:32 | -0.03 | rest |
| 00:01:33 | -0.518 | rest |
| 00:01:34 | 0.113 | rest |
| 00:01:35 | -0.675 | rest |
| 00:01:36 | -1.611 | rest |
| 00:01:37 | 1.157 | rest |
| 00:01:38 | 30.825 | a quiet |
| 00:01:39 | 38.985 | a quiet |
| 00:01:40 | 38.271 | a quiet |
| 00:01:41 | 39.77 | a quiet |
| 00:01:42 | 36.663 | a quiet |
| 00:01:43 | 34.842 | a quiet |
| 00:01:44 | 38.346 | a quiet |
| 00:01:45 | 37.784 | a quiet |
| 00:01:46 | 34.674 | a quiet |
| 00:01:47 | 31.749 | a quiet |
| 00:01:48 | 30.036 | a quiet |
| 00:01:49 | 27.648 | a quiet |

| | | |
|---|---|---|
| 00:01:50 | 25.172 | a quiet |
| 00:01:51 | 24.329 | a quiet |
| 00:01:52 | 22.881 | a quiet |
| 00:01:53 | 22.496 | a quiet |
| 00:01:54 | 19.27 | a quiet |
| 00:01:55 | 17.967 | a quiet |
| 00:01:56 | 11.774 | a quiet |
| 00:01:57 | 0.057 | rest |
| 00:01:58 | -3.132 | rest |
| 00:01:59 | 33.412 | spontaneous |
| 00:02:00 | 31.406 | spontaneous |
| 00:02:01 | 31.622 | spontaneous |
| 00:02:02 | 0.07 | rest |
| 00:02:03 | -1.538 | rest |
| 00:02:04 | 0.194 | rest |
| 00:02:05 | 0.201 | rest |
| 00:02:06 | 0.008 | rest |
| 00:02:07 | -0.009 | rest |
| 00:02:08 | -0.039 | rest |
| 00:02:09 | 0.137 | rest |
| 00:02:10 | -1.175 | rest |
| 00:02:11 | 3.518 | rest |
| 00:02:12 | 47.798 | a low |
| 00:02:13 | 40.527 | a low |
| 00:02:14 | 38.108 | a low |
| 00:02:15 | 36.61 | a low |
| 00:02:16 | 34.411 | a low |
| 00:02:17 | 32.468 | a low |
| 00:02:18 | 32.182 | a low |
| 00:02:19 | 33.004 | a low |

| | | |
|---|---|---|
| 00:02:20 | 31.134 | a low |
| 00:02:21 | 29.608 | a low |
| 00:02:22 | 0.547 | rest |
| 00:02:23 | -0.06 | rest |
| 00:02:24 | -0.893 | rest |
| 00:02:25 | 0.559 | rest |
| 00:02:26 | 0.121 | rest |
| 00:02:27 | 0.129 | rest |
| 00:02:28 | 0.015 | rest |
| 00:02:29 | 0.078 | rest |
| 00:02:30 | -0.002 | rest |
| 00:02:31 | -2.817 | rest |
| 00:02:32 | 41.715 | a high |
| 00:02:33 | 47.723 | a high |
| 00:02:34 | 48.185 | a high |
| 00:02:35 | 42.863 | a high |
| 00:02:36 | 5.188 | a high |
| 00:02:37 | -1.728 | rest |
| 00:02:38 | 0.029 | rest |
| 00:02:39 | 0.002 | rest |
| 00:02:40 | -0.023 | rest |
| 00:02:41 | -0.623 | rest |
| 00:02:42 | 0.151 | rest |
| 00:02:43 | -0.91 | rest |
| 00:02:44 | 0.276 | rest |
| 00:02:45 | -3.237 | rest |
| 00:02:46 | 47.715 | a loud |
| 00:02:47 | 72.838 | a loud |
| 00:02:48 | 67.792 | a loud |
| 00:02:49 | 57.678 | a loud |

| | | |
|---|---|---|
| 00:02:50 | 44.003 | a loud |
| 00:02:51 | 1.862 | a loud |
| 00:02:52 | 0.009 | rest |
| 00:02:53 | -4.202 | rest |
| 00:02:54 | 34.838 | spontaneous |
| 00:02:55 | 35.712 | spontaneous |
| 00:02:56 | 26.826 | spontaneous |
| 00:02:57 | 0.647 | rest |
| 00:02:58 | -0.056 | rest |
| 00:02:59 | -0.138 | rest |
| 00:03:00 | -0.016 | rest |
| 00:03:01 | -0.055 | rest |
| 00:03:02 | 0.284 | rest |
| 00:03:03 | -0.08 | rest |
| 00:03:04 | 0.045 | rest |
| 00:03:05 | -0.015 | rest |
| 00:03:06 | -0.03 | rest |

***STL3***

| **FLUKE time** | **mmHg** | **Condition** |
|---|---|---|
| 00:00:00 | 0.002 | rest |
| 00:00:01 | 0.11 | rest |
| 00:00:02 | 0.211 | rest |
| 00:00:03 | -0.527 | rest |
| 00:00:04 | 0.608 | rest |
| 00:00:05 | -0.807 | rest |
| 00:00:06 | 0.255 | rest |
| 00:00:07 | -0.124 | rest |
| 00:00:08 | 0.59 | rest |

| | | |
|---|---|---|
| 00:00:09 | -0.674 | rest |
| 00:00:10 | -0.587 | rest |
| 00:00:11 | -0.012 | rest |
| 00:00:12 | 31.55 | spontaneous |
| 00:00:13 | 3.524 | spontaneous |
| 00:00:14 | -0.295 | spontaneous |
| 00:00:15 | 19.868 | spontaneous |
| 00:00:16 | 26.35 | spontaneous |
| 00:00:17 | 6.364 | spontaneous |
| 00:00:18 | 21.761 | spontaneous |
| 00:00:19 | 3.772 | spontaneous |
| 00:00:20 | 0.125 | spontaneous |
| 00:00:21 | 25.147 | spontaneous |
| 00:00:22 | 23.05 | spontaneous |
| 00:00:23 | 2.963 | spontaneous |
| 00:00:24 | 14.73 | spontaneous |
| 00:00:25 | 4.886 | spontaneous |
| 00:00:26 | -1.31 | spontaneous |
| 00:00:27 | 3.814 | spontaneous |
| 00:00:28 | 29.81 | spontaneous |
| 00:00:29 | 21.836 | spontaneous |
| 00:00:30 | 6.182 | spontaneous |
| 00:00:31 | 19.712 | spontaneous |
| 00:00:32 | 28.747 | spontaneous |
| 00:00:33 | 16.383 | spontaneous |
| 00:00:34 | 25.633 | spontaneous |
| 00:00:35 | 2.338 | spontaneous |
| 00:00:36 | -0.83 | rest |
| 00:00:37 | 0.4 | rest |
| 00:00:38 | -0.117 | rest |

| | | |
|---|---|---|
| 00:00:39 | 0.157 | rest |
| 00:00:40 | -0.509 | rest |
| 00:00:41 | 24.538 | spontaneous |
| 00:00:42 | 23.923 | spontaneous |
| 00:00:43 | 21.666 | spontaneous |
| 00:00:44 | 21.201 | spontaneous |
| 00:00:45 | 1.025 | spontaneous |
| 00:00:46 | -1.043 | spontaneous |
| 00:00:47 | 21.948 | spontaneous |
| 00:00:48 | 7.478 | spontaneous |
| 00:00:49 | 27.461 | spontaneous |
| 00:00:50 | 2.043 | spontaneous |
| 00:00:51 | 21.158 | spontaneous |
| 00:00:52 | 25.715 | spontaneous |
| 00:00:53 | -0.121 | spontaneous |
| 00:00:54 | 28.038 | spontaneous |
| 00:00:55 | 5.976 | spontaneous |
| 00:00:56 | -1.555 | spontaneous |
| 00:00:57 | 1.775 | spontaneous |
| 00:00:58 | 1.892 | spontaneous |
| 00:00:59 | 23.998 | spontaneous |
| 00:01:00 | 24.514 | spontaneous |
| 00:01:01 | -0.479 | spontaneous |
| 00:01:02 | 0.747 | spontaneous |
| 00:01:03 | 4.959 | spontaneous |
| 00:01:04 | 25.643 | spontaneous |
| 00:01:05 | 21.853 | spontaneous |
| 00:01:06 | 4.903 | spontaneous |
| 00:01:07 | 13.739 | spontaneous |
| 00:01:08 | -0.197 | spontaneous |

| | | |
|---|---|---|
| 00:01:09 | 0.012 | spontaneous |
| 00:01:10 | 9.612 | spontaneous |
| 00:01:11 | 26.273 | spontaneous |
| 00:01:12 | 26.794 | spontaneous |
| 00:01:13 | 1.074 | spontaneous |
| 00:01:14 | 0.031 | spontaneous |
| 00:01:15 | 2.975 | spontaneous |
| 00:01:16 | 26.636 | spontaneous |
| 00:01:17 | 29.361 | spontaneous |
| 00:01:18 | 15.431 | spontaneous |
| 00:01:19 | -0.229 | spontaneous |
| 00:01:20 | 28.99 | spontaneous |
| 00:01:21 | 19.833 | spontaneous |
| 00:01:22 | 1.359 | spontaneous |
| 00:01:23 | -0.312 | spontaneous |
| 00:01:24 | 19.178 | spontaneous |
| 00:01:25 | 26.726 | spontaneous |
| 00:01:26 | 3.431 | spontaneous |
| 00:01:27 | 25.513 | spontaneous |
| 00:01:28 | 17.847 | spontaneous |
| 00:01:29 | 21.018 | spontaneous |
| 00:01:30 | 14.444 | spontaneous |
| 00:01:31 | -1.339 | rest |
| 00:01:32 | 0.136 | rest |
| 00:01:33 | 0.64 | rest |
| 00:01:34 | -1.283 | rest |
| 00:01:35 | 0.749 | rest |
| 00:01:36 | -0.222 | rest |
| 00:01:37 | -0.091 | rest |
| 00:01:38 | 0.608 | rest |

| | | |
|---|---|---|
| 00:01:39 | -0.705 | rest |
| 00:01:40 | 0.037 | rest |
| 00:01:41 | 0.374 | rest |
| 00:01:42 | -0.861 | rest |
| 00:01:43 | 0.043 | rest |
| 00:01:44 | 28.713 | spontaneous |
| 00:01:45 | 6.484 | spontaneous |
| 00:01:46 | 29.581 | spontaneous |
| 00:01:47 | 4.688 | spontaneous |
| 00:01:48 | -0.915 | spontaneous |
| 00:01:49 | 24.464 | spontaneous |
| 00:01:50 | 22.935 | spontaneous |
| 00:01:51 | 11.486 | spontaneous |
| 00:01:52 | -0.799 | spontaneous |
| 00:01:53 | 1.898 | spontaneous |
| 00:01:54 | 27.024 | spontaneous |
| 00:01:55 | 5.671 | spontaneous |
| 00:01:56 | -0.028 | spontaneous |
| 00:01:57 | 33.409 | spontaneous |
| 00:01:58 | 6.211 | spontaneous |
| 00:01:59 | 16.992 | spontaneous |
| 00:02:00 | 17.593 | spontaneous |
| 00:02:01 | 20.373 | spontaneous |
| 00:02:02 | 4.344 | spontaneous |
| 00:02:03 | -0.502 | spontaneous |
| 00:02:04 | 30.676 | spontaneous |
| 00:02:05 | 7.468 | spontaneous |
| 00:02:06 | -0.808 | spontaneous |
| 00:02:07 | 33.819 | spontaneous |
| 00:02:08 | 6.091 | spontaneous |

| | | |
|---|---|---|
| 00:02:09 | -0.943 | spontaneous |
| 00:02:10 | -0.615 | spontaneous |
| 00:02:11 | 20.061 | spontaneous |
| 00:02:12 | 0.571 | spontaneous |
| 00:02:13 | -0.207 | spontaneous |
| 00:02:14 | 33.521 | spontaneous |
| 00:02:15 | 19.254 | spontaneous |
| 00:02:16 | 0.929 | spontaneous |
| 00:02:17 | -0.281 | spontaneous |
| 00:02:18 | 0.116 | spontaneous |
| 00:02:19 | 24.96 | spontaneous |
| 00:02:20 | 21.536 | spontaneous |
| 00:02:21 | 23.62 | spontaneous |
| 00:02:22 | 23.663 | spontaneous |
| 00:02:23 | 21.658 | spontaneous |
| 00:02:24 | 21.339 | spontaneous |
| 00:02:25 | -0.284 | spontaneous |
| 00:02:26 | -0.62 | spontaneous |
| 00:02:27 | 28.592 | spontaneous |
| 00:02:28 | 16.822 | spontaneous |
| 00:02:29 | 23.72 | spontaneous |
| 00:02:30 | -1.348 | spontaneous |
| 00:02:31 | 25.002 | spontaneous |
| 00:02:32 | 45.358 | spontaneous |
| 00:02:33 | 2.948 | spontaneous |
| 00:02:34 | 10.133 | spontaneous |
| 00:02:35 | 25.455 | spontaneous |
| 00:02:36 | 7.256 | spontaneous |
| 00:02:37 | 21.771 | spontaneous |
| 00:02:38 | -0.062 | spontaneous |

| | | |
|---|---|---|
| 00:02:39 | -0.268 | spontaneous |
| 00:02:40 | 0.734 | spontaneous |
| 00:02:41 | 10.991 | spontaneous |
| 00:02:42 | -1.204 | spontaneous |
| 00:02:43 | -0.135 | spontaneous |
| 00:02:44 | 38.9 | spontaneous |
| 00:02:45 | 8.757 | spontaneous |
| 00:02:46 | 0.394 | rest |
| 00:02:47 | -0.931 | rest |
| 00:02:48 | 0.471 | rest |
| 00:02:49 | -0.599 | rest |
| 00:02:50 | 0.194 | rest |
| 00:02:51 | -0.276 | rest |
| 00:02:52 | 0.658 | rest |
| 00:02:53 | -0.435 | rest |
| 00:02:54 | 1.028 | rest |
| 00:02:55 | 0.082 | rest |
| 00:02:56 | -1.187 | rest |
| 00:02:57 | -0.399 | rest |
| 00:02:58 | 0.467 | rest |
| 00:02:59 | 32.372 | sentence 1 |
| 00:03:00 | 27.27 | sentence 1 |
| 00:03:01 | 21.988 | sentence 1 |
| 00:03:02 | 1.133 | sentence 1 |
| 00:03:03 | -0.229 | rest |
| 00:03:04 | -0.206 | rest |
| 00:03:05 | 0.761 | rest |
| 00:03:06 | -0.693 | rest |
| 00:03:07 | 0.743 | rest |
| 00:03:08 | -0.751 | rest |

| | | |
|---|---|---|
| 00:03:09 | 6.855 | sentence 2 |
| 00:03:10 | 24.963 | sentence 2 |
| 00:03:11 | 26.254 | sentence 2 |
| 00:03:12 | 0.871 | rest |
| 00:03:13 | -0.664 | rest |
| 00:03:14 | 0.496 | rest |
| 00:03:15 | 0.363 | rest |
| 00:03:16 | -0.774 | rest |
| 00:03:17 | -0.418 | rest |
| 00:03:18 | 25.139 | sentence 3 |
| 00:03:19 | 19.985 | sentence 3 |
| 00:03:20 | 15.212 | sentence 3 |
| 00:03:21 | 0.492 | rest |
| 00:03:22 | -0.301 | rest |
| 00:03:23 | 0.067 | rest |
| 00:03:24 | 0.526 | rest |
| 00:03:25 | 0.486 | rest |
| 00:03:26 | 0.221 | rest |
| 00:03:27 | 0.101 | rest |
| 00:03:28 | -1.299 | rest |
| 00:03:29 | 0.937 | rest |
| 00:03:30 | 0.41 | rest |
| 00:03:31 | -0.632 | rest |
| 00:03:32 | 0.683 | rest |
| 00:03:33 | 0.038 | rest |
| 00:03:34 | 0.18 | rest |
| 00:03:35 | 0.053 | rest |
| 00:03:36 | -0.883 | rest |
| 00:03:37 | 0.123 | rest |
| 00:03:38 | 24.85 | a comfortable |

| | | |
|---|---|---|
| 00:03:39 | 21.329 | a comfortable |
| 00:03:40 | 20.158 | a comfortable |
| 00:03:41 | 18.808 | a comfortable |
| 00:03:42 | 18.319 | a comfortable |
| 00:03:43 | 20.005 | a comfortable |
| 00:03:44 | 20.189 | a comfortable |
| 00:03:45 | 20.261 | a comfortable |
| 00:03:46 | 22.695 | a comfortable |
| 00:03:47 | 22.143 | a comfortable |
| 00:03:48 | 22.399 | a comfortable |
| 00:03:49 | 24.547 | a comfortable |
| 00:03:50 | 20.867 | a comfortable |
| 00:03:51 | 2.275 | a comfortable |
| 00:03:52 | -1.959 | rest |
| 00:03:53 | 0.562 | rest |
| 00:03:54 | 0.457 | rest |
| 00:03:55 | -1.725 | rest |
| 00:03:56 | 0.674 | rest |
| 00:03:57 | 0.1 | rest |
| 00:03:58 | -0.415 | rest |
| 00:03:59 | -0.216 | rest |
| 00:04:00 | 0.568 | rest |
| 00:04:01 | -0.877 | rest |
| 00:04:02 | 0.213 | rest |
| 00:04:03 | 0.084 | rest |
| 00:04:04 | 0.062 | rest |
| 00:04:05 | 14.955 | a quiet |
| 00:04:06 | 13.439 | a quiet |
| 00:04:07 | 10.732 | a quiet |
| 00:04:08 | 10.588 | a quiet |

| | | |
|---|---|---|
| 00:04:09 | 9.975 | a quiet |
| 00:04:10 | 7.502 | a quiet |
| 00:04:11 | 0.854 | a quiet |
| 00:04:12 | -1.029 | rest |
| 00:04:13 | 0.257 | rest |
| 00:04:14 | -0.982 | rest |
| 00:04:15 | 0.033 | rest |
| 00:04:16 | 9.076 | a low |
| 00:04:17 | 25.447 | a low |
| 00:04:18 | 22.351 | a low |
| 00:04:19 | 21.755 | a low |
| 00:04:20 | 24.196 | a low |
| 00:04:21 | 27.442 | a low |
| 00:04:22 | 24.259 | a low |
| 00:04:23 | -0.058 | rest |
| 00:04:24 | 0.174 | rest |
| 00:04:25 | -0.931 | rest |
| 00:04:26 | 0.758 | rest |
| 00:04:27 | 0.068 | rest |
| 00:04:28 | 0.476 | rest |
| 00:04:29 | -0.535 | rest |
| 00:04:30 | -0.149 | rest |
| 00:04:31 | 8.919 | a high |
| 00:04:32 | 19.772 | a high |
| 00:04:33 | 24.083 | a high |
| 00:04:34 | 27.674 | a high |
| 00:04:35 | 28.089 | a high |
| 00:04:36 | 26.707 | a high |
| 00:04:37 | 26.801 | a high |
| 00:04:38 | 25.633 | a high |

| | | |
|---|---|---|
| 00:04:39 | 17.686 | a high |
| 00:04:40 | -0.989 | rest |
| 00:04:41 | 0.518 | rest |
| 00:04:42 | 0.087 | rest |
| 00:04:43 | 0.091 | rest |
| 00:04:44 | 0.025 | rest |
| 00:04:45 | 0.439 | rest |
| 00:04:46 | 0.152 | rest |
| 00:04:47 | 0.049 | rest |
| 00:04:48 | 0.2 | rest |
| 00:04:49 | -0.692 | rest |
| 00:04:50 | 39.662 | a loud |
| 00:04:51 | 41.167 | a loud |
| 00:04:52 | 48.262 | a loud |
| 00:04:53 | 46.5 | a loud |
| 00:04:54 | 1.1 | a loud |
| 00:04:55 | 0.243 | rest |
| 00:04:56 | -0.09 | rest |
| 00:04:57 | 0.261 | rest |

***STL4***

| **FLUKE time** | **mmHg** | **Condition** |
|---|---|---|
| 00:00:00 | 0.219 | rest |
| 00:00:01 | 0.193 | rest |
| 00:00:02 | -0.525 | rest |
| 00:00:03 | 0.154 | rest |
| 00:00:04 | 0.089 | rest |
| 00:00:05 | -0.339 | rest |
| 00:00:06 | 0.95 | rest |

| | | |
|---|---|---|
| 00:00:07 | -0.924 | rest |
| 00:00:08 | 0.758 | rest |
| 00:00:09 | -0.196 | rest |
| 00:00:10 | 0.394 | rest |
| 00:00:11 | -0.076 | rest |
| 00:00:12 | -0.492 | rest |
| 00:00:13 | -0.36 | rest |
| 00:00:14 | 23.345 | spontaneous |
| 00:00:15 | 21.848 | spontaneous |
| 00:00:16 | -1.933 | spontaneous |
| 00:00:17 | 21.459 | spontaneous |
| 00:00:18 | 5.541 | spontaneous |
| 00:00:19 | 22.987 | spontaneous |
| 00:00:20 | 14.154 | spontaneous |
| 00:00:21 | 9.341 | spontaneous |
| 00:00:22 | 19.393 | spontaneous |
| 00:00:23 | 12.329 | spontaneous |
| 00:00:24 | 0.322 | spontaneous |
| 00:00:25 | 1.46 | spontaneous |
| 00:00:26 | 11.026 | spontaneous |
| 00:00:27 | 3.111 | spontaneous |
| 00:00:28 | 17.885 | spontaneous |
| 00:00:29 | -0.786 | rest |
| 00:00:30 | 0.053 | rest |
| 00:00:31 | -0.341 | rest |
| 00:00:32 | 0.52 | rest |
| 00:00:33 | 0.008 | rest |
| 00:00:34 | 0.116 | rest |
| 00:00:35 | 0.019 | rest |
| 00:00:36 | 0.295 | rest |

| | | |
|---|---|---|
| 00:00:37 | 0.019 | rest |
| 00:00:38 | -0.039 | rest |
| 00:00:39 | 0.015 | rest |
| 00:00:40 | -5.936 | rest |
| 00:00:41 | 20.205 | comfortable a |
| 00:00:42 | 39.172 | comfortable a |
| 00:00:43 | 30.436 | comfortable a |
| 00:00:44 | 27.37 | comfortable a |
| 00:00:45 | 23.139 | comfortable a |
| 00:00:46 | 23.67 | comfortable a |
| 00:00:47 | 22.148 | comfortable a |
| 00:00:48 | 25.059 | comfortable a |
| 00:00:49 | 27.302 | comfortable a |
| 00:00:50 | 23.207 | comfortable a |
| 00:00:51 | -6.294 | rest |
| 00:00:52 | 5.871 | rest |
| 00:00:53 | -0.78 | rest |
| 00:00:54 | -0.026 | rest |
| 00:00:55 | -0.355 | rest |
| 00:00:56 | 0.021 | rest |
| 00:00:57 | -0.024 | rest |
| 00:00:58 | -1.034 | rest |
| 00:00:59 | 0.312 | rest |
| 00:01:00 | 0.217 | rest |
| 00:01:01 | 0.071 | rest |
| 00:01:02 | 0.091 | rest |
| 00:01:03 | -1.675 | rest |
| 00:01:04 | 0.307 | rest |
| 00:01:05 | 34.399 | comfortable a |
| 00:01:06 | 28.907 | comfortable a |

| | | |
|---|---|---|
| 00:01:07 | 27.462 | comfortable a |
| 00:01:08 | 24.512 | comfortable a |
| 00:01:09 | 23.941 | comfortable a |
| 00:01:10 | 26.031 | comfortable a |
| 00:01:11 | 29.649 | comfortable a |
| 00:01:12 | 4.788 | comfortable a |
| 00:01:13 | -0.795 | rest |
| 00:01:14 | -0.661 | rest |
| 00:01:15 | 0.062 | rest |
| 00:01:16 | 0.027 | rest |
| 00:01:17 | 0.025 | rest |
| 00:01:18 | 0.005 | rest |
| 00:01:19 | -0.022 | rest |
| 00:01:20 | 0.032 | rest |
| 00:01:21 | 0.009 | rest |
| 00:01:22 | -0.001 | rest |
| 00:01:23 | 0.15 | rest |
| 00:01:24 | -0.034 | rest |
| 00:01:25 | -0.713 | rest |
| 00:01:26 | 1.027 | rest |
| 00:01:27 | -2.567 | rest |
| 00:01:28 | 40.541 | low |
| 00:01:29 | 40.377 | low |
| 00:01:30 | 34.418 | low |
| 00:01:31 | 25.169 | low |
| 00:01:32 | -0.027 | rest |
| 00:01:33 | 0.02 | rest |
| 00:01:34 | 0.121 | rest |
| 00:01:35 | 0.167 | rest |
| 00:01:36 | -0.736 | rest |

| | | |
|---|---|---|
| 00:01:37 | 0.47 | rest |
| 00:01:38 | -3.813 | rest |
| 00:01:39 | 11.898 | quiet |
| 00:01:40 | 11.618 | quiet |
| 00:01:41 | 16.648 | quiet |
| 00:01:42 | 17.083 | quiet |
| 00:01:43 | 17.826 | quiet |
| 00:01:44 | 17.264 | quiet |
| 00:01:45 | 18.253 | quiet |
| 00:01:46 | 16.608 | quiet |
| 00:01:47 | 19.072 | quiet |
| 00:01:48 | 0.949 | rest |
| 00:01:49 | -0.73 | rest |
| 00:01:50 | -0.005 | rest |
| 00:01:51 | 0.074 | rest |
| 00:01:52 | -0.101 | rest |
| 00:01:53 | 0.017 | rest |
| 00:01:54 | -0.007 | rest |
| 00:01:55 | -1.38 | rest |
| 00:01:56 | 0.897 | rest |
| 00:01:57 | -0.948 | rest |
| 00:01:58 | 20.883 | high |
| 00:01:59 | 36.07 | high |
| 00:02:00 | 29.76 | high |
| 00:02:01 | 30.396 | high |
| 00:02:02 | -2.392 | rest |
| 00:02:03 | -0.425 | rest |
| 00:02:04 | 18.484 | rest |
| 00:02:05 | 1.126 | rest |
| 00:02:06 | 0.021 | rest |

| | | |
|---|---|---|
| 00:02:07 | 0.021 | rest |
| 00:02:08 | 0.023 | rest |
| 00:02:09 | -0.043 | rest |
| 00:02:10 | 0.011 | rest |
| 00:02:11 | -1.722 | rest |
| 00:02:12 | 2.411 | rest |
| 00:02:13 | 0.121 | rest |
| 00:02:14 | 0.332 | rest |
| 00:02:15 | -2.839 | rest |
| 00:02:16 | 6.275 | rest |
| 00:02:17 | 60.249 | loud |
| 00:02:18 | 47.104 | loud |
| 00:02:19 | 41.007 | loud |
| 00:02:20 | 37.221 | loud |
| 00:02:21 | 0.476 | rest |
| 00:02:22 | -0.182 | rest |
| 00:02:23 | 0.086 | rest |
| 00:02:24 | 0.029 | rest |
| 00:02:25 | 0.024 | rest |
| 00:02:26 | 0.528 | rest |
| 00:02:27 | 0.051 | rest |
| 00:02:28 | -0.244 | rest |
| 00:02:29 | -0.158 | rest |
| 00:02:30 | 0.075 | rest |
| 00:02:31 | 0.022 | rest |
| 00:02:32 | -0.05 | rest |
| 00:02:33 | 0.051 | rest |
| 00:02:34 | 0.006 | rest |
| 00:02:35 | 0.029 | rest |
| 00:02:36 | 0.022 | rest |

| | | |
|---|---|---|
| 00:02:37 | -0.085 | rest |
| 00:02:38 | 0.013 | rest |
| 00:02:39 | 0.399 | rest |
| 00:02:40 | -1.781 | rest |
| 00:02:41 | 2.039 | rest |
| 00:02:42 | 0.328 | rest |
| 00:02:43 | -3.974 | rest |
| 00:02:44 | -0.268 | rest |
| 00:02:45 | 26.635 | glowing |
| 00:02:46 | 38.296 | glowing |
| 00:02:47 | 38.274 | glowing |
| 00:02:48 | 40.932 | glowing |
| 00:02:49 | 37.857 | glowing |
| 00:02:50 | 36.22 | glowing |
| 00:02:51 | -1.432 | rest |
| 00:02:52 | 0.228 | rest |
| 00:02:53 | -0.304 | rest |
| 00:02:54 | 1.001 | rest |
| 00:02:55 | 0.055 | rest |
| 00:02:56 | 0.032 | rest |
| 00:02:57 | 0.037 | rest |
| 00:02:58 | 0.042 | rest |
| 00:02:59 | 0.061 | rest |
| 00:03:00 | 0.045 | rest |
| 00:03:01 | 0.498 | rest |
| 00:03:02 | 0.036 | rest |
| 00:03:03 | 0.272 | rest |
| 00:03:04 | -0.977 | rest |
| 00:03:05 | -0.268 | rest |
| 00:03:06 | 13.309 | sentence 2 |

| | | |
|---|---|---|
| 00:03:07 | 10.166 | sentence 2 |
| 00:03:08 | 24.079 | sentence 2 |
| 00:03:09 | 21.577 | sentence 2 |
| 00:03:10 | 0.259 | rest |
| 00:03:11 | 0.013 | rest |
| 00:03:12 | 0.013 | rest |
| 00:03:13 | 0.026 | rest |
| 00:03:14 | 0.05 | rest |
| 00:03:15 | 0.092 | rest |
| 00:03:16 | -1.392 | rest |
| 00:03:17 | 29.844 | sentence 3 |
| 00:03:18 | 39.464 | sentence 3 |
| 00:03:19 | 6.3 | sentence 3 |
| 00:03:20 | 11.887 | sentence 3 |
| 00:03:21 | 19.658 | sentence 3 |
| 00:03:22 | -1.442 | rest |
| 00:03:23 | -0.3 | rest |
| 00:03:24 | -0.458 | rest |
| 00:03:25 | 0.079 | rest |
| 00:03:26 | -0.047 | rest |
| 00:03:27 | 0.005 | rest |
| 00:03:28 | 0.005 | rest |
| 00:03:29 | -0.83 | rest |
| 00:03:30 | 1.866 | rest |
| 00:03:31 | -1.391 | rest |
| 00:03:32 | -1.194 | rest |
| 00:03:33 | 24.969 | sentence 1 |
| 00:03:34 | 1.29 | sentence 1 |
| 00:03:35 | 25.321 | sentence 1 |
| 00:03:36 | 22.44 | sentence 1 |

| | | |
|---|---|---|
| 00:03:37 | 5.403 | sentence 1 |
| 00:03:38 | -0.504 | rest |
| 00:03:39 | 0.033 | rest |
| 00:03:40 | -0.025 | rest |
| 00:03:41 | 0.049 | rest |
| 00:03:42 | -0.046 | rest |
| 00:03:43 | 0.035 | rest |
| 00:03:44 | -0.051 | rest |
| 00:03:45 | 0.2 | rest |
| 00:03:46 | 0.027 | rest |
| 00:03:47 | 0.005 | rest |
| 00:03:48 | 0.016 | rest |
| 00:03:49 | 0.028 | rest |
| 00:03:50 | 0.032 | rest |
| 00:03:51 | 0.027 | rest |
| 00:03:52 | 0.079 | rest |
| 00:03:53 | -0.062 | rest |
| 00:03:54 | 0.81 | rest |
| 00:03:55 | 0.001 | rest |
| 00:03:56 | -1.334 | rest |
| 00:03:57 | -0.211 | rest |

***STL5***

| FLUKE time | mmHg | Condition |
|---|---|---|
| 00:00:00 | 0.413 | rest |
| 00:00:01 | -0.199 | rest |
| 00:00:02 | 0.603 | rest |
| 00:00:03 | 0.301 | rest |
| 00:00:04 | 0.27 | rest |

| | | |
|---|---|---|
| 00:00:05 | 0.07 | rest |
| 00:00:06 | -0.197 | rest |
| 00:00:07 | 0.074 | rest |
| 00:00:08 | 26.642 | spontaneous |
| 00:00:09 | 24.819 | spontaneous |
| 00:00:10 | 22.681 | spontaneous |
| 00:00:11 | 16.058 | spontaneous |
| 00:00:12 | 22.076 | spontaneous |
| 00:00:13 | 19.758 | spontaneous |
| 00:00:14 | 17.242 | spontaneous |
| 00:00:15 | 21.764 | spontaneous |
| 00:00:16 | 0.509 | rest |
| 00:00:17 | -0.407 | rest |
| 00:00:18 | 0.279 | rest |
| 00:00:19 | 0.63 | rest |
| 00:00:20 | 22.59 | spontaneous |
| 00:00:21 | 22.99 | spontaneous |
| 00:00:22 | 16.638 | spontaneous |
| 00:00:23 | 1.99 | spontaneous |
| 00:00:24 | 19.685 | spontaneous |
| 00:00:25 | -0.169 | rest |
| 00:00:26 | 0.18 | rest |
| 00:00:27 | 0.282 | rest |
| 00:00:28 | 11.622 | spontaneous |
| 00:00:29 | 28.483 | spontaneous |
| 00:00:30 | 30.58 | spontaneous |
| 00:00:31 | 27.641 | spontaneous |
| 00:00:32 | 19.641 | spontaneous |
| 00:00:33 | 17.576 | spontaneous |
| 00:00:34 | 19.65 | spontaneous |

| | | |
|---|---|---|
| 00:00:35 | 19.07 | spontaneous |
| 00:00:36 | -0.093 | rest |
| 00:00:37 | -0.5 | rest |
| 00:00:38 | 0.584 | rest |
| 00:00:39 | 0.331 | rest |
| 00:00:40 | -0.305 | rest |
| 00:00:41 | 0.511 | rest |
| 00:00:42 | 0.401 | rest |
| 00:00:43 | 0.297 | rest |
| 00:00:44 | -0.294 | rest |
| 00:00:45 | -0.262 | rest |
| 00:00:46 | -0.827 | rest |
| 00:00:47 | 0.152 | rest |
| 00:00:48 | 65.19 | comfortable a |
| 00:00:49 | 54.622 | comfortable a |
| 00:00:50 | 47.792 | comfortable a |
| 00:00:51 | 47.232 | comfortable a |
| 00:00:52 | 48.898 | comfortable a |
| 00:00:53 | 46.999 | comfortable a |
| 00:00:54 | 43.033 | comfortable a |
| 00:00:55 | 37.732 | comfortable a |
| 00:00:56 | 33.833 | comfortable a |
| 00:00:57 | 28.48 | comfortable a |
| 00:00:58 | 0.364 | rest |
| 00:00:59 | -0.16 | rest |
| 00:01:00 | 0.147 | rest |
| 00:01:01 | 0.326 | rest |
| 00:01:02 | 0.509 | rest |
| 00:01:03 | 0.225 | rest |
| 00:01:04 | 0.609 | rest |

| | | |
|---|---|---|
| 00:01:05 | -0.84 | rest |
| 00:01:06 | -0.388 | rest |
| 00:01:07 | 34.989 | comfortable a |
| 00:01:08 | 46.953 | comfortable a |
| 00:01:09 | 45.044 | comfortable a |
| 00:01:10 | 44.249 | comfortable a |
| 00:01:11 | 43.46 | comfortable a |
| 00:01:12 | 38.307 | comfortable a |
| 00:01:13 | 34.768 | comfortable a |
| 00:01:14 | 38.801 | comfortable a |
| 00:01:15 | 36.581 | comfortable a |
| 00:01:16 | 25.507 | comfortable a |
| 00:01:17 | -0.001 | rest |
| 00:01:18 | 0.338 | rest |
| 00:01:19 | 0.295 | rest |
| 00:01:20 | 0.266 | rest |
| 00:01:21 | 0.297 | rest |
| 00:01:22 | 0.287 | rest |
| 00:01:23 | 0.258 | rest |
| 00:01:24 | 0.285 | rest |
| 00:01:25 | -0.106 | rest |
| 00:01:26 | 0.912 | rest |
| 00:01:27 | -1.556 | rest |
| 00:01:28 | 0.013 | rest |
| 00:01:29 | 0.257 | rest |
| 00:01:30 | 55.212 | low a |
| 00:01:31 | 55.611 | low a |
| 00:01:32 | 54.41 | low a |
| 00:01:33 | 34.238 | low a |
| 00:01:34 | 0.65 | rest |

| | | |
|---|---|---|
| 00:01:35 | -0.078 | rest |
| 00:01:36 | 0.511 | rest |
| 00:01:37 | 0.301 | rest |
| 00:01:38 | 0.31 | rest |
| 00:01:39 | -0.48 | rest |
| 00:01:40 | -0.651 | rest |
| 00:01:41 | 0.284 | rest |
| 00:01:42 | 19.302 | quiet a |
| 00:01:43 | 17.885 | quiet a |
| 00:01:44 | 20.219 | quiet a |
| 00:01:45 | 1.913 | rest |
| 00:01:46 | -0.062 | rest |
| 00:01:47 | 0.316 | rest |
| 00:01:48 | 0.326 | rest |
| 00:01:49 | 0.295 | rest |
| 00:01:50 | -0.787 | rest |
| 00:01:51 | 40.008 | high a |
| 00:01:52 | 44.289 | high a |
| 00:01:53 | 34.079 | high a |
| 00:01:54 | 36.066 | high a |
| 00:01:55 | 33.499 | high a |
| 00:01:56 | 0.016 | rest |
| 00:01:57 | 0.234 | rest |
| 00:01:58 | 0.329 | rest |
| 00:01:59 | 0.305 | rest |
| 00:02:00 | -0.659 | rest |
| 00:02:01 | -0.891 | rest |
| 00:02:02 | 105.105 | loud a |
| 00:02:03 | 93.638 | loud a |
| 00:02:04 | 91.778 | loud a |

| | | |
|---|---|---|
| 00:02:05 | 76.089 | loud a |
| 00:02:06 | 0.69 | rest |
| 00:02:07 | 0.368 | rest |
| 00:02:08 | -0.379 | rest |
| 00:02:09 | 0.182 | rest |
| 00:02:10 | 0.758 | rest |
| 00:02:11 | 0.348 | rest |
| 00:02:12 | -0.09 | rest |
| 00:02:13 | 0.846 | rest |
| 00:02:14 | 0.342 | rest |
| 00:02:15 | 0.245 | rest |
| 00:02:16 | -0.287 | rest |
| 00:02:17 | 1.171 | rest |
| 00:02:18 | 10.314 | glowing |
| 00:02:19 | 57.647 | glowing |
| 00:02:20 | 42.956 | glowing |
| 00:02:21 | 39.617 | glowing |
| 00:02:22 | 1.082 | rest |
| 00:02:23 | 1.983 | rest |
| 00:02:24 | -0.613 | rest |
| 00:02:25 | 22.379 | spontaneous |
| 00:02:26 | 17.333 | spontaneous |
| 00:02:27 | 10.374 | spontaneous |
| 00:02:28 | -0.064 | spontaneous |
| 00:02:29 | 0.375 | spontaneous |
| 00:02:30 | 14.416 | spontaneous |
| 00:02:31 | 21.134 | spontaneous |
| 00:02:32 | 0.575 | rest |
| 00:02:33 | -0.449 | rest |
| 00:02:34 | -1.816 | rest |

| | | |
|---|---|---|
| 00:02:35 | 51.321 | glowing |
| 00:02:36 | 71.454 | glowing |
| 00:02:37 | 57.847 | glowing |
| 00:02:38 | 6.429 | spontaneous |
| 00:02:39 | 5.174 | spontaneous |
| 00:02:40 | 0.238 | rest |
| 00:02:41 | 0.431 | rest |
| 00:02:42 | 0.404 | rest |
| 00:02:43 | -0.273 | rest |
| 00:02:44 | 0.61 | rest |
| 00:02:45 | 0.317 | rest |
| 00:02:46 | 0.292 | rest |
| 00:02:47 | 0.167 | rest |
| 00:02:48 | 0.357 | rest |
| 00:02:49 | 0.423 | rest |
| 00:02:50 | 0.402 | rest |
| 00:02:51 | -0.192 | rest |
| 00:02:52 | -0.403 | rest |
| 00:02:53 | 1.787 | rest |
| 00:02:54 | 34.846 | sentence 2 |
| 00:02:55 | 30.858 | sentence 2 |
| 00:02:56 | 0.873 | rest |
| 00:02:57 | -0.013 | rest |
| 00:02:58 | 0.672 | rest |
| 00:02:59 | 0.279 | rest |
| 00:03:00 | 0.088 | rest |
| 00:03:01 | 0.449 | rest |
| 00:03:02 | 0.32 | rest |
| 00:03:03 | 0.278 | rest |
| 00:03:04 | -0.902 | rest |

| | | |
|---|---|---|
| 00:03:05 | 46.347 | sentence 3 |
| 00:03:06 | 44.204 | sentence 3 |
| 00:03:07 | 0.773 | rest |
| 00:03:08 | 0.02 | rest |
| 00:03:09 | -0.191 | rest |
| 00:03:10 | 0.555 | rest |
| 00:03:11 | 0.185 | rest |
| 00:03:12 | 9.458 | sentence 1 |
| 00:03:13 | 31.443 | sentence 1 |
| 00:03:14 | 28.806 | sentence 1 |
| 00:03:15 | 0.373 | rest |
| 00:03:16 | 0.057 | rest |
| 00:03:17 | 0.63 | rest |
| 00:03:18 | -0.089 | rest |
| 00:03:19 | 0.675 | rest |
| 00:03:20 | 0.455 | rest |
| 00:03:21 | -1.126 | rest |

***STL6***

| **FLUKE time** | **mmHg** | **Condition** |
|---|---|---|
| 00:00:00 | 0.029 | rest |
| 00:00:01 | -0.063 | rest |
| 00:00:02 | 0.195 | rest |
| 00:00:03 | 0.084 | rest |
| 00:00:04 | -0.139 | rest |
| 00:00:05 | 0.227 | rest |
| 00:00:06 | 0.114 | rest |
| 00:00:07 | 0.069 | rest |
| 00:00:08 | -0.042 | rest |

| | | |
|---|---|---|
| 00:00:09 | 0.094 | rest |
| 00:00:10 | 0.069 | rest |
| 00:00:11 | 0.06 | rest |
| 00:00:12 | -0.252 | rest |
| 00:00:13 | -0.183 | rest |
| 00:00:14 | -0.331 | rest |
| 00:00:15 | 0.543 | rest |
| 00:00:16 | -0.457 | rest |
| 00:00:17 | -0.545 | rest |
| 00:00:18 | 1.415 | rest |
| 00:00:19 | 27.669 | spontaneous |
| 00:00:20 | 11.82 | spontaneous |
| 00:00:21 | 45.753 | spontaneous |
| 00:00:22 | -0.103 | spontaneous |
| 00:00:23 | 31.457 | spontaneous |
| 00:00:24 | 27.18 | spontaneous |
| 00:00:25 | 33.763 | spontaneous |
| 00:00:26 | 32.703 | spontaneous |
| 00:00:27 | 32.778 | spontaneous |
| 00:00:28 | -1.813 | spontaneous |
| 00:00:29 | 38.221 | spontaneous |
| 00:00:30 | 33.213 | spontaneous |
| 00:00:31 | 33.488 | spontaneous |
| 00:00:32 | 29.692 | spontaneous |
| 00:00:33 | 40.987 | spontaneous |
| 00:00:34 | -1.443 | spontaneous |
| 00:00:35 | 31.391 | spontaneous |
| 00:00:36 | 44.67 | spontaneous |
| 00:00:37 | 11.91 | spontaneous |
| 00:00:38 | 37.331 | spontaneous |

| | | |
|---|---|---|
| 00:00:39 | 1.91 | spontaneous |
| 00:00:40 | 31.653 | spontaneous |
| 00:00:41 | 18.65 | spontaneous |
| 00:00:42 | 41.789 | spontaneous |
| 00:00:43 | 43.327 | spontaneous |
| 00:00:44 | 47.092 | spontaneous |
| 00:00:45 | 42.968 | spontaneous |
| 00:00:46 | 40.332 | spontaneous |
| 00:00:47 | -1.311 | spontaneous |
| 00:00:48 | 48.554 | spontaneous |
| 00:00:49 | 44.22 | spontaneous |
| 00:00:50 | 41.214 | spontaneous |
| 00:00:51 | 31.886 | spontaneous |
| 00:00:52 | 40.678 | spontaneous |
| 00:00:53 | 5.038 | spontaneous |
| 00:00:54 | 24.549 | spontaneous |
| 00:00:55 | -0.113 | spontaneous |
| 00:00:56 | 27.651 | spontaneous |
| 00:00:57 | 50.42 | spontaneous |
| 00:00:58 | 47.924 | spontaneous |
| 00:00:59 | 46.85 | spontaneous |
| 00:01:00 | 31.167 | spontaneous |
| 00:01:01 | 37.118 | spontaneous |
| 00:01:02 | 2.178 | spontaneous |
| 00:01:03 | 0.123 | rest |
| 00:01:04 | 0.082 | rest |
| 00:01:05 | 0.04 | rest |
| 00:01:06 | 0.109 | rest |
| 00:01:07 | -0.09 | rest |
| 00:01:08 | 0.105 | rest |

| | | |
|---|---|---|
| 00:01:09 | 0.061 | rest |
| 00:01:10 | -2.895 | rest |
| 00:01:11 | 7.89 | comfortable a |
| 00:01:12 | 42.182 | comfortable a |
| 00:01:13 | 40.975 | comfortable a |
| 00:01:14 | 42.663 | comfortable a |
| 00:01:15 | 41.402 | comfortable a |
| 00:01:16 | 43.077 | comfortable a |
| 00:01:17 | 37.669 | comfortable a |
| 00:01:18 | 39.43 | comfortable a |
| 00:01:19 | 35.936 | comfortable a |
| 00:01:20 | 37.019 | comfortable a |
| 00:01:21 | 35.955 | comfortable a |
| 00:01:22 | 34.05 | comfortable a |
| 00:01:23 | 35.585 | comfortable a |
| 00:01:24 | 31.246 | comfortable a |
| 00:01:25 | 44.338 | comfortable a |
| 00:01:26 | -0.741 | rest |
| 00:01:27 | 0.679 | rest |
| 00:01:28 | 0.177 | rest |
| 00:01:29 | -7.337 | rest |
| 00:01:30 | 6.557 | spontaneous |
| 00:01:31 | 27.931 | spontaneous |
| 00:01:32 | -1.465 | spontaneous |
| 00:01:33 | 41.236 | spontaneous |
| 00:01:34 | 32.324 | spontaneous |
| 00:01:35 | 0.158 | spontaneous |
| 00:01:36 | -1.629 | spontaneous |
| 00:01:37 | 40.742 | spontaneous |
| 00:01:38 | 0.775 | rest |

| | | |
|---|---|---|
| 00:01:39 | 0.19 | rest |
| 00:01:40 | 0.094 | rest |
| 00:01:41 | 0.079 | rest |
| 00:01:42 | 0.062 | rest |
| 00:01:43 | -0.407 | rest |
| 00:01:44 | -3.802 | rest |
| 00:01:45 | 40.949 | comfortable a |
| 00:01:46 | 45.686 | comfortable a |
| 00:01:47 | 40.924 | comfortable a |
| 00:01:48 | 46.081 | comfortable a |
| 00:01:49 | 45.379 | comfortable a |
| 00:01:50 | 41.624 | comfortable a |
| 00:01:51 | 45.099 | comfortable a |
| 00:01:52 | 31.71 | comfortable a |
| 00:01:53 | 28.569 | comfortable a |
| 00:01:54 | 34.286 | comfortable a |
| 00:01:55 | 0.083 | rest |
| 00:01:56 | -1.244 | rest |
| 00:01:57 | 0.181 | rest |
| 00:01:58 | 0.107 | rest |
| 00:01:59 | 0.078 | rest |
| 00:02:00 | -2.314 | rest |
| 00:02:01 | 0.386 | rest |
| 00:02:02 | 0.136 | rest |
| 00:02:03 | 0.092 | rest |
| 00:02:04 | 0.066 | rest |
| 00:02:05 | 0.225 | rest |
| 00:02:06 | 0.106 | rest |
| 00:02:07 | 0.08 | rest |
| 00:02:08 | -0.041 | rest |

| | | |
|---|---|---|
| 00:02:09 | 0.083 | rest |
| 00:02:10 | -0.578 | rest |
| 00:02:11 | 0.836 | rest |
| 00:02:12 | 0.077 | rest |
| 00:02:13 | 35.426 | rest |
| 00:02:14 | -0.38 | rest |
| 00:02:15 | 4.065 | rest |
| 00:02:16 | 39.568 | low a |
| 00:02:17 | 41.971 | low a |
| 00:02:18 | 43.891 | low a |
| 00:02:19 | 43.723 | low a |
| 00:02:20 | 45.871 | low a |
| 00:02:21 | 43.191 | low a |
| 00:02:22 | 49.274 | low a |
| 00:02:23 | 0.172 | rest |
| 00:02:24 | 0.11 | rest |
| 00:02:25 | -0.281 | rest |
| 00:02:26 | 0.349 | rest |
| 00:02:27 | -1.702 | rest |
| 00:02:28 | 35.31 | rest |
| 00:02:29 | 0.329 | rest |
| 00:02:30 | -0.553 | rest |
| 00:02:31 | 1.119 | rest |
| 00:02:32 | 0.237 | rest |
| 00:02:33 | 0.108 | rest |
| 00:02:34 | 0.083 | rest |
| 00:02:35 | -0.969 | rest |
| 00:02:36 | -0.493 | rest |
| 00:02:37 | 18.308 | quiet a |
| 00:02:38 | 20.021 | quiet a |

| | | |
|---|---|---|
| 00:02:39 | 24.111 | quiet a |
| 00:02:40 | 25.957 | quiet a |
| 00:02:41 | 26.521 | quiet a |
| 00:02:42 | 26.994 | quiet a |
| 00:02:43 | 24.093 | quiet a |
| 00:02:44 | 0.204 | rest |
| 00:02:45 | 0.111 | rest |
| 00:02:46 | 0.082 | rest |
| 00:02:47 | 0.075 | rest |
| 00:02:48 | 0.072 | rest |
| 00:02:49 | -0.034 | rest |
| 00:02:50 | 0.076 | rest |
| 00:02:51 | 0.071 | rest |
| 00:02:52 | 0.08 | rest |
| 00:02:53 | -1.769 | rest |
| 00:02:54 | 36.215 | high a |
| 00:02:55 | 39.503 | high a |
| 00:02:56 | 39.595 | high a |
| 00:02:57 | 44.667 | high a |
| 00:02:58 | 45.918 | high a |
| 00:02:59 | 31.306 | high a |
| 00:03:00 | 0.092 | rest |
| 00:03:01 | -0.2 | rest |
| 00:03:02 | 0.422 | rest |
| 00:03:03 | 0.112 | rest |
| 00:03:04 | 0.085 | rest |
| 00:03:05 | 0.076 | rest |
| 00:03:06 | 0.072 | rest |
| 00:03:07 | -0.92 | rest |
| 00:03:08 | 0.149 | rest |

| | | |
|---|---|---|
| 00:03:09 | 0.105 | rest |
| 00:03:10 | -0.565 | rest |
| 00:03:11 | 65.601 | loud a |
| 00:03:12 | 95.434 | loud a |
| 00:03:13 | 86.209 | loud a |
| 00:03:14 | 80.729 | loud a |
| 00:03:15 | 41.38 | loud a |
| 00:03:16 | 4.302 | loud a |
| 00:03:17 | -0.776 | rest |
| 00:03:18 | 2.433 | rest |
| 00:03:19 | 0.378 | rest |
| 00:03:20 | 0.111 | rest |
| 00:03:21 | 0.172 | rest |
| 00:03:22 | -4.826 | rest |
| 00:03:23 | 47.475 | spontaneous |
| 00:03:24 | 31.406 | spontaneous |
| 00:03:25 | 0.388 | rest |
| 00:03:26 | 0.107 | rest |
| 00:03:27 | 0.137 | rest |
| 00:03:28 | 0.091 | rest |
| 00:03:29 | 0.08 | rest |
| 00:03:30 | 0.075 | rest |
| 00:03:31 | 0.069 | rest |
| 00:03:32 | 0.071 | rest |
| 00:03:33 | 0.006 | rest |
| 00:03:34 | 0.081 | rest |
| 00:03:35 | -0.139 | rest |
| 00:03:36 | -1.603 | rest |
| 00:03:37 | 31.25 | glowing |
| 00:03:38 | 53.033 | glowing |

| | | |
|---|---|---|
| 00:03:39 | 59.206 | glowing |
| 00:03:40 | 59.725 | glowing |
| 00:03:41 | 62.297 | glowing |
| 00:03:42 | 22.467 | glowing |
| 00:03:43 | 0.108 | rest |
| 00:03:44 | -0.657 | rest |
| 00:03:45 | -0.548 | rest |
| 00:03:46 | 0.232 | rest |
| 00:03:47 | 0.11 | rest |
| 00:03:48 | 0.087 | rest |
| 00:03:49 | -0.813 | rest |
| 00:03:50 | 0.283 | rest |
| 00:03:51 | 0.116 | rest |
| 00:03:52 | 0.092 | rest |
| 00:03:53 | -0.334 | rest |
| 00:03:54 | 0.46 | rest |
| 00:03:55 | 46.104 | sentence 2 |
| 00:03:56 | 40.343 | sentence 2 |
| 00:03:57 | 13.37 | sentence 2 |
| 00:03:58 | 0.179 | rest |
| 00:03:59 | 0.104 | rest |
| 00:04:00 | 0.082 | rest |
| 00:04:01 | 0.053 | rest |
| 00:04:02 | -1.529 | rest |
| 00:04:03 | 48.285 | sentence 3 |
| 00:04:04 | 46.183 | sentence 3 |
| 00:04:05 | 40.968 | sentence 3 |
| 00:04:06 | 14.706 | sentence 3 |
| 00:04:07 | 0.135 | rest |
| 00:04:08 | 0.095 | rest |

| | | |
|---|---|---|
| 00:04:09 | 0.083 | rest |
| 00:04:10 | 0.089 | rest |
| 00:04:11 | 0.086 | rest |
| 00:04:12 | 0.054 | rest |
| 00:04:13 | 7.445 | sentence 1 |
| 00:04:14 | 44.875 | sentence 1 |
| 00:04:15 | 39.525 | sentence 1 |
| 00:04:16 | 42.529 | sentence 1 |
| 00:04:17 | 29.953 | sentence 1 |
| 00:04:18 | 0.11 | rest |
| 00:04:19 | 0.088 | rest |
| 00:04:20 | -0.58 | rest |
| 00:04:21 | 8.774 | rest |

***STL7***

| **FLUKE time** | **mmHg** | **Condition** |
|---|---|---|
| 00:00:00 | -0.149 | rest |
| 00:00:01 | 0.02 | rest |
| 00:00:02 | 0.08 | rest |
| 00:00:03 | 0.042 | rest |
| 00:00:04 | 0.068 | rest |
| 00:00:05 | 0.043 | rest |
| 00:00:06 | -0.442 | rest |
| 00:00:07 | 0.211 | rest |
| 00:00:08 | 0.061 | rest |
| 00:00:09 | 0.04 | rest |
| 00:00:10 | 0.06 | rest |
| 00:00:11 | 0.048 | rest |
| 00:00:12 | 0.032 | rest |

| | | |
|---|---|---|
| 00:00:13 | 0.055 | rest |
| 00:00:14 | 0.045 | rest |
| 00:00:15 | 0.039 | rest |
| 00:00:16 | 0.038 | rest |
| 00:00:17 | -0.066 | rest |
| 00:00:18 | -0.715 | rest |
| 00:00:19 | 22.185 | spontaneous |
| 00:00:20 | 21.17 | spontaneous |
| 00:00:21 | 22.802 | spontaneous |
| 00:00:22 | -1.081 | spontaneous |
| 00:00:23 | 18.042 | spontaneous |
| 00:00:24 | 2.339 | spontaneous |
| 00:00:25 | 11.526 | spontaneous |
| 00:00:26 | 18.487 | spontaneous |
| 00:00:27 | 4.252 | spontaneous |
| 00:00:28 | 17.569 | spontaneous |
| 00:00:29 | 3.743 | spontaneous |
| 00:00:30 | 19.433 | spontaneous |
| 00:00:31 | 21.17 | spontaneous |
| 00:00:32 | 16.474 | spontaneous |
| 00:00:33 | 2.242 | spontaneous |
| 00:00:34 | 17.48 | spontaneous |
| 00:00:35 | 0.121 | spontaneous |
| 00:00:36 | 17.807 | spontaneous |
| 00:00:37 | 17.774 | spontaneous |
| 00:00:38 | 1.343 | spontaneous |
| 00:00:39 | 18.274 | spontaneous |
| 00:00:40 | 4.79 | spontaneous |
| 00:00:41 | 23.295 | spontaneous |
| 00:00:42 | 17.421 | spontaneous |

| | | |
|---|---|---|
| 00:00:43 | 12.11 | spontaneous |
| 00:00:44 | 19.81 | spontaneous |
| 00:00:45 | 12.84 | spontaneous |
| 00:00:46 | 18.095 | spontaneous |
| 00:00:47 | 18.132 | spontaneous |
| 00:00:48 | 19.853 | spontaneous |
| 00:00:49 | 13.598 | spontaneous |
| 00:00:50 | 17.24 | spontaneous |
| 00:00:51 | -0.392 | spontaneous |
| 00:00:52 | 17.958 | spontaneous |
| 00:00:53 | 14.167 | spontaneous |
| 00:00:54 | 13.027 | spontaneous |
| 00:00:55 | 9.168 | spontaneous |
| 00:00:56 | 18.207 | spontaneous |
| 00:00:57 | 0.125 | spontaneous |
| 00:00:58 | 12.75 | spontaneous |
| 00:00:59 | 0.449 | spontaneous |
| 00:01:00 | 18.959 | spontaneous |
| 00:01:01 | 19.357 | spontaneous |
| 00:01:02 | 15.494 | spontaneous |
| 00:01:03 | -1.469 | spontaneous |
| 00:01:04 | 1.376 | spontaneous |
| 00:01:05 | 20.859 | spontaneous |
| 00:01:06 | -0.942 | spontaneous |
| 00:01:07 | 15.848 | spontaneous |
| 00:01:08 | 15.783 | spontaneous |
| 00:01:09 | 7.296 | spontaneous |
| 00:01:10 | 21.373 | spontaneous |
| 00:01:11 | 17.452 | spontaneous |
| 00:01:12 | 0.156 | spontaneous |

| | | |
|---|---|---|
| 00:01:13 | 15.233 | spontaneous |
| 00:01:14 | -0.621 | spontaneous |
| 00:01:15 | 8.967 | spontaneous |
| 00:01:16 | 16.75 | spontaneous |
| 00:01:17 | 19.635 | spontaneous |
| 00:01:18 | 2.277 | spontaneous |
| 00:01:19 | 16.924 | spontaneous |
| 00:01:20 | 18.007 | spontaneous |
| 00:01:21 | 13.378 | spontaneous |
| 00:01:22 | 16.376 | spontaneous |
| 00:01:23 | 14.89 | spontaneous |
| 00:01:24 | 19.154 | spontaneous |
| 00:01:25 | 21.991 | spontaneous |
| 00:01:26 | -0.122 | spontaneous |
| 00:01:27 | 8.357 | spontaneous |
| 00:01:28 | 18.548 | spontaneous |
| 00:01:29 | 3.407 | spontaneous |
| 00:01:30 | 17.212 | spontaneous |
| 00:01:31 | -0.354 | spontaneous |
| 00:01:32 | 23.01 | spontaneous |
| 00:01:33 | 0.068 | rest |
| 00:01:34 | 0.023 | rest |

Second recording

| | | |
|---|---|---|
| 00:00:00 | 0.167 | rest |
| 00:00:01 | 0.013 | rest |
| 00:00:02 | -0.016 | rest |
| 00:00:03 | 0.048 | rest |
| 00:00:04 | -0.035 | rest |
| 00:00:05 | 0.009 | rest |

| | | |
|---|---|---|
| 00:00:06 | -0.321 | rest |
| 00:00:07 | -0.013 | rest |
| 00:00:08 | 0.195 | rest |
| 00:00:09 | 0.106 | rest |
| 00:00:10 | 0.017 | rest |
| 00:00:11 | -0.007 | rest |
| 00:00:12 | -0.197 | rest |
| 00:00:13 | -0.349 | rest |
| 00:00:14 | 24.427 | comfortable |
| 00:00:15 | 24.312 | comfortable |
| 00:00:16 | 23.846 | comfortable |
| 00:00:17 | 25.082 | comfortable |
| 00:00:18 | 29.13 | comfortable |
| 00:00:19 | 29.542 | comfortable |
| 00:00:20 | 33.742 | comfortable |
| 00:00:21 | 4.64 | rest |
| 00:00:22 | -0.055 | rest |
| 00:00:23 | -0.268 | rest |
| 00:00:24 | 0.027 | rest |
| 00:00:25 | 0.212 | rest |
| 00:00:26 | 0.023 | rest |
| 00:00:27 | -0.217 | rest |
| 00:00:28 | 0.092 | rest |
| 00:00:29 | 0.049 | rest |
| 00:00:30 | -0.08 | rest |
| 00:00:31 | 0.021 | rest |
| 00:00:32 | 0.059 | rest |
| 00:00:33 | -0.647 | rest |
| 00:00:34 | -0.425 | rest |
| 00:00:35 | 27.698 | comfortable |

| | | |
|---|---|---|
| 00:00:36 | 26.817 | comfortable |
| 00:00:37 | 26.593 | comfortable |
| 00:00:38 | 29.028 | comfortable |
| 00:00:39 | 30.995 | comfortable |
| 00:00:40 | 29.866 | comfortable |
| 00:00:41 | 28.987 | comfortable |
| 00:00:42 | 0.108 | rest |
| 00:00:43 | 0.016 | rest |
| 00:00:44 | 0.014 | rest |
| 00:00:45 | 0.064 | rest |
| 00:00:46 | 0.047 | rest |
| 00:00:47 | -0.248 | rest |
| 00:00:48 | 0.037 | rest |
| 00:00:49 | 0.004 | rest |
| 00:00:50 | 0.069 | rest |
| 00:00:51 | -0.288 | rest |
| 00:00:52 | 0.001 | rest |
| 00:00:53 | 0.062 | rest |
| 00:00:54 | 0.02 | rest |
| 00:00:55 | 0.022 | rest |
| 00:00:56 | 0.004 | rest |
| 00:00:57 | 0.029 | rest |
| 00:00:58 | 0.026 | rest |
| 00:00:59 | 0.037 | rest |
| 00:01:00 | 0.003 | rest |
| 00:01:01 | -0.423 | rest |
| 00:01:02 | -0.175 | rest |
| 00:01:03 | -0.579 | rest |
| 00:01:04 | 0.215 | rest |
| 00:01:05 | -0.04 | rest |

| | | |
|---|---|---|
| 00:01:06 | 32.704 | low |
| 00:01:07 | 30.872 | low |
| 00:01:08 | 30.326 | low |
| 00:01:09 | 30.208 | low |
| 00:01:10 | 30.552 | low |
| 00:01:11 | 0.344 | rest |
| 00:01:12 | 0.136 | rest |
| 00:01:13 | -0.094 | rest |
| 00:01:14 | 0.135 | rest |
| 00:01:15 | -1.182 | rest |
| 00:01:16 | 0.112 | rest |
| 00:01:17 | 0.03 | rest |
| 00:01:18 | 0.217 | rest |
| 00:01:19 | 0.059 | rest |
| 00:01:20 | -0.982 | rest |
| 00:01:21 | 0.452 | rest |
| 00:01:22 | 0.055 | rest |
| 00:01:23 | -0.309 | rest |
| 00:01:24 | 9.23 | rest |
| 00:01:25 | 16.998 | rest |
| 00:01:26 | -1.887 | rest |
| 00:01:27 | 10.331 | quiet |
| 00:01:28 | 8.661 | quiet |
| 00:01:29 | 6.993 | quiet |
| 00:01:30 | 6.772 | quiet |
| 00:01:31 | 7.438 | quiet |
| 00:01:32 | 6.917 | quiet |
| 00:01:33 | 0.192 | rest |
| 00:01:34 | 0.066 | rest |
| 00:01:35 | 0.065 | rest |

| | | |
|---|---|---|
| 00:01:36 | -0.086 | rest |
| 00:01:37 | 0.043 | rest |
| 00:01:38 | 0.028 | rest |
| 00:01:39 | -0.011 | rest |
| 00:01:40 | 0.047 | rest |
| 00:01:41 | 0.037 | rest |
| 00:01:42 | -0.006 | rest |
| 00:01:43 | -0.639 | rest |
| 00:01:44 | 0.046 | rest |
| 00:01:45 | 0.23 | rest |
| 00:01:46 | -0.722 | rest |
| 00:01:47 | 14.292 | high |
| 00:01:48 | 16.513 | high |
| 00:01:49 | 19.362 | high |
| 00:01:50 | 17.185 | high |
| 00:01:51 | 18.359 | high |
| 00:01:52 | 17.023 | high |
| 00:01:53 | 0.201 | rest |
| 00:01:54 | 0.214 | rest |
| 00:01:55 | 0.335 | rest |
| 00:01:56 | 0.086 | rest |
| 00:01:57 | -0.217 | rest |
| 00:01:58 | 0.092 | rest |
| 00:01:59 | 0.042 | rest |
| 00:02:00 | 0.054 | rest |
| 00:02:01 | -0.113 | rest |
| 00:02:02 | -0.704 | rest |
| 00:02:03 | 0.084 | rest |
| 00:02:04 | -0.393 | rest |
| 00:02:05 | -0.396 | rest |

| | | |
|---|---|---|
| 00:02:06 | 0.052 | rest |
| 00:02:07 | 0.412 | rest |
| 00:02:08 | -0.635 | rest |
| 00:02:09 | 53.464 | loud |
| 00:02:10 | 57.006 | loud |
| 00:02:11 | 53.677 | loud |
| 00:02:12 | 42.14 | loud |
| 00:02:13 | -0.195 | rest |
| 00:02:14 | 0.61 | rest |
| 00:02:15 | 0.054 | rest |
| 00:02:16 | 0.217 | rest |
| 00:02:17 | 0.039 | rest |
| 00:02:18 | 0 | rest |
| 00:02:19 | 0.038 | rest |
| 00:02:20 | 0.028 | rest |
| 00:02:21 | 0.019 | rest |
| 00:02:22 | 0.067 | rest |
| 00:02:23 | -0.654 | rest |
| 00:02:24 | 0.269 | rest |
| 00:02:25 | 0.679 | rest |
| 00:02:26 | 0.046 | rest |
| 00:02:27 | -0.346 | rest |
| 00:02:28 | -0.05 | rest |
| 00:02:29 | 0.086 | rest |
| 00:02:30 | -0.336 | rest |
| 00:02:31 | -0.425 | rest |
| 00:02:32 | 0.331 | rest |
| 00:02:33 | -0.373 | rest |
| 00:02:34 | 4.99 | rest |
| 00:02:35 | 24.184 | glowing |

| | | |
|---|---|---|
| 00:02:36 | 20.886 | glowing |
| 00:02:37 | 23.945 | glowing |
| 00:02:38 | 25.873 | glowing |
| 00:02:39 | 25.28 | glowing |
| 00:02:40 | 24.981 | glowing |
| 00:02:41 | 7.024 | rest |
| 00:02:42 | -0.036 | rest |
| 00:02:43 | 0.011 | rest |
| 00:02:44 | 0.112 | rest |
| 00:02:45 | -0.292 | rest |
| 00:02:46 | 17.934 | spontaneous |
| 00:02:47 | 23.533 | spontaneous |
| 00:02:48 | 3.666 | spontaneous |
| 00:02:49 | 0.04 | rest |
| 00:02:50 | -0.024 | rest |
| 00:02:51 | 0.376 | rest |
| 00:02:52 | -0.013 | rest |
| 00:02:53 | 0.033 | rest |
| 00:02:54 | 0.021 | rest |
| 00:02:55 | 0.034 | rest |
| 00:02:56 | 0.045 | rest |
| 00:02:57 | -0.018 | rest |
| 00:02:58 | 0.034 | rest |
| 00:02:59 | 0.093 | rest |
| 00:03:00 | -0.007 | rest |
| 00:03:01 | 0.005 | rest |
| 00:03:02 | 0.03 | rest |
| 00:03:03 | 0.05 | rest |
| 00:03:04 | 0.044 | rest |
| 00:03:05 | 0.048 | rest |

| | | |
|---|---|---|
| 00:03:06 | 0.096 | rest |
| 00:03:07 | -0.082 | rest |
| 00:03:08 | -0.001 | rest |
| 00:03:09 | 0.012 | rest |
| 00:03:10 | 0.021 | rest |
| 00:03:11 | 0.099 | rest |
| 00:03:12 | -0.012 | rest |
| 00:03:13 | -0.522 | rest |
| 00:03:14 | 0.306 | rest |
| 00:03:15 | -0.484 | rest |
| 00:03:16 | -0.231 | rest |
| 00:03:17 | 7.33 | sentence 2 |
| 00:03:18 | 11.985 | sentence 2 |
| 00:03:19 | 2.375 | sentence 2 |
| 00:03:20 | 15.068 | sentence 2 |
| 00:03:21 | 14.733 | sentence 2 |
| 00:03:22 | 0.225 | rest |
| 00:03:23 | -0.021 | rest |
| 00:03:24 | 0.051 | rest |
| 00:03:25 | 0.037 | rest |
| 00:03:26 | 0.031 | rest |
| 00:03:27 | -0.774 | rest |
| 00:03:28 | 21.567 | sentence 3 |
| 00:03:29 | 16.048 | sentence 3 |
| 00:03:30 | 11.93 | sentence 3 |
| 00:03:31 | 3.389 | sentence 3 |
| 00:03:32 | 0.082 | rest |
| 00:03:33 | 0.033 | rest |
| 00:03:34 | 0.029 | rest |
| 00:03:35 | 0.027 | rest |

| | | |
|---|---|---|
| 00:03:36 | -0.931 | rest |
| 00:03:37 | 18.282 | sentence 1 |
| 00:03:38 | 20.477 | sentence 1 |
| 00:03:39 | 19.508 | sentence 1 |
| 00:03:40 | 18.197 | sentence 1 |
| 00:03:41 | 4.517 | rest |
| 00:03:42 | 0.078 | rest |
| 00:03:43 | -0.015 | rest |
| 00:03:44 | 0.008 | rest |
| 00:03:45 | 0.017 | rest |
| 00:03:46 | -0.04 | rest |
| 00:03:47 | -0.128 | rest |

***STL8***

| **FLUKE time** | **mmHg** | **Condition** |
|---|---|---|
| 00:00:00 | 0.027 | rest |
| 00:00:01 | -0.049 | rest |
| 00:00:02 | 0.097 | rest |
| 00:00:03 | 0.018 | rest |
| 00:00:04 | -0.402 | rest |
| 00:00:05 | 0.117 | rest |
| 00:00:06 | 0.034 | rest |
| 00:00:07 | -0.638 | rest |
| 00:00:08 | 0.173 | rest |
| 00:00:09 | -0.036 | rest |
| 00:00:10 | -2.824 | rest |
| 00:00:11 | 12.357 | spontaneous |
| 00:00:12 | 23.707 | spontaneous |
| 00:00:13 | 29.898 | spontaneous |

| | | |
|---|---|---|
| 00:00:14 | 24.634 | spontaneous |
| 00:00:15 | 6.738 | spontaneous |
| 00:00:16 | 0.185 | rest |
| 00:00:17 | 0.106 | rest |
| 00:00:18 | -0.069 | rest |
| 00:00:19 | 8.419 | spontaneous |
| 00:00:20 | 16.554 | spontaneous |
| 00:00:21 | 7.546 | spontaneous |
| 00:00:22 | 19.994 | spontaneous |
| 00:00:23 | 27.205 | spontaneous |
| 00:00:24 | 12.814 | spontaneous |
| 00:00:25 | 15.064 | spontaneous |
| 00:00:26 | 5.696 | spontaneous |
| 00:00:27 | 10.909 | spontaneous |
| 00:00:28 | -1.379 | rest |
| 00:00:29 | -0.056 | rest |
| 00:00:30 | 0.487 | rest |
| 00:00:31 | -2.704 | rest |
| 00:00:32 | 1.025 | rest |
| 00:00:33 | 20.775 | spontaneous |
| 00:00:34 | 23.398 | spontaneous |
| 00:00:35 | 25.707 | spontaneous |
| 00:00:36 | 28.025 | spontaneous |
| 00:00:37 | 24.948 | spontaneous |
| 00:00:38 | 32.987 | spontaneous |
| 00:00:39 | -3.063 | spontaneous |
| 00:00:40 | 29.974 | spontaneous |
| 00:00:41 | 30.974 | spontaneous |
| 00:00:42 | 25.079 | spontaneous |
| 00:00:43 | 29.601 | spontaneous |

| | | |
|---|---|---|
| 00:00:44 | 0.801 | spontaneous |
| 00:00:45 | 25.982 | spontaneous |
| 00:00:46 | 22.34 | spontaneous |
| 00:00:47 | 14.375 | spontaneous |
| 00:00:48 | 21.433 | spontaneous |
| 00:00:49 | 20.736 | spontaneous |
| 00:00:50 | -0.183 | spontaneous |
| 00:00:51 | 18.782 | spontaneous |
| 00:00:52 | 21.533 | spontaneous |
| 00:00:53 | 22.213 | spontaneous |
| 00:00:54 | 23.503 | spontaneous |
| 00:00:55 | 21.193 | spontaneous |
| 00:00:56 | 17.767 | spontaneous |
| 00:00:57 | 23.906 | spontaneous |
| 00:00:58 | 27.001 | spontaneous |
| 00:00:59 | 14.453 | spontaneous |
| 00:01:00 | 18.001 | spontaneous |
| 00:01:01 | 12.299 | spontaneous |
| 00:01:02 | 6.666 | spontaneous |
| 00:01:03 | 0.599 | rest |
| 00:01:04 | -1.625 | rest |
| 00:01:05 | 0.75 | rest |
| 00:01:06 | 0.026 | rest |
| 00:01:07 | -4.23 | rest |
| 00:01:08 | -0.894 | rest |
| 00:01:09 | 0.231 | rest |
| 00:01:10 | 8.862 | comfortable a |
| 00:01:11 | 16.026 | comfortable a |
| 00:01:12 | 15.554 | comfortable a |
| 00:01:13 | 15.56 | comfortable a |

| | | |
|---|---|---|
| 00:01:14 | 15.741 | comfortable a |
| 00:01:15 | 16.573 | comfortable a |
| 00:01:16 | 17.286 | comfortable a |
| 00:01:17 | 17.585 | comfortable a |
| 00:01:18 | 18.57 | comfortable a |
| 00:01:19 | 18.478 | comfortable a |
| 00:01:20 | 18.801 | comfortable a |
| 00:01:21 | 19.564 | comfortable a |
| 00:01:22 | 19.838 | comfortable a |
| 00:01:23 | 19.959 | comfortable a |
| 00:01:24 | 20.055 | comfortable a |
| 00:01:25 | 20.237 | comfortable a |
| 00:01:26 | 20.3 | comfortable a |
| 00:01:27 | 20.782 | comfortable a |
| 00:01:28 | 20.349 | comfortable a |
| 00:01:29 | 20.154 | comfortable a |
| 00:01:30 | 21.064 | comfortable a |
| 00:01:31 | 21.646 | comfortable a |
| 00:01:32 | 21.539 | comfortable a |
| 00:01:33 | 21.636 | comfortable a |
| 00:01:34 | 22.115 | comfortable a |
| 00:01:35 | 22.408 | comfortable a |
| 00:01:36 | 22.478 | comfortable a |
| 00:01:37 | 22.738 | comfortable a |
| 00:01:38 | 22.645 | comfortable a |
| 00:01:39 | 23.421 | comfortable a |
| 00:01:40 | 23.703 | comfortable a |
| 00:01:41 | 23.802 | comfortable a |
| 00:01:42 | 24.178 | comfortable a |
| 00:01:43 | 24.039 | comfortable a |

| | | |
|---|---|---|
| 00:01:44 | 22.628 | comfortable a |
| 00:01:45 | 26.395 | comfortable a |
| 00:01:46 | 26.562 | comfortable a |
| 00:01:47 | 24.639 | comfortable a |
| 00:01:48 | 27.48 | comfortable a |
| 00:01:49 | 27.414 | comfortable a |
| 00:01:50 | 26.422 | comfortable a |
| 00:01:51 | 28.05 | comfortable a |
| 00:01:52 | 26.584 | comfortable a |
| 00:01:53 | -0.296 | rest |
| 00:01:54 | -1.723 | rest |
| 00:01:55 | -2.538 | rest |
| 00:01:56 | 2.203 | rest |
| 00:01:57 | 0.607 | rest |
| 00:01:58 | -1.964 | rest |
| 00:01:59 | 0.994 | rest |
| 00:02:00 | -3.781 | rest |
| 00:02:01 | 0.022 | rest |
| 00:02:02 | 40.229 | spontaneous |
| 00:02:03 | 40.003 | spontaneous |
| 00:02:04 | 28.153 | spontaneous |
| 00:02:05 | 1.282 | rest |
| 00:02:06 | 0.013 | rest |
| 00:02:07 | 0.414 | rest |
| 00:02:08 | -2.338 | rest |
| 00:02:09 | 2.068 | rest |
| 00:02:10 | -0.395 | rest |
| 00:02:11 | 1.323 | rest |
| 00:02:12 | 0.259 | rest |
| 00:02:13 | 0.075 | rest |

| | | |
|---|---|---|
| 00:02:14 | -0.171 | rest |
| 00:02:15 | 0.09 | rest |
| 00:02:16 | -2.98 | rest |
| 00:02:17 | 4.404 | rest |
| 00:02:18 | 13.992 | low |
| 00:02:19 | 13.715 | low |
| 00:02:20 | 12.916 | low |
| 00:02:21 | 12.615 | low |
| 00:02:22 | 12.197 | low |
| 00:02:23 | 0.797 | rest |
| 00:02:24 | 0.129 | rest |
| 00:02:25 | -0.827 | rest |
| 00:02:26 | 0.13 | rest |
| 00:02:27 | 11.712 | quiet |
| 00:02:28 | 9.855 | quiet |
| 00:02:29 | 9.534 | quiet |
| 00:02:30 | 8.847 | quiet |
| 00:02:31 | 8.728 | quiet |
| 00:02:32 | 0.575 | rest |
| 00:02:33 | 0.177 | rest |
| 00:02:34 | -0.039 | rest |
| 00:02:35 | -3.287 | rest |
| 00:02:36 | 3.6 | rest |
| 00:02:37 | 22.519 | high |
| 00:02:38 | 16.362 | high |
| 00:02:39 | 16.466 | high |
| 00:02:40 | 16.163 | high |
| 00:02:41 | 11.618 | high |
| 00:02:42 | 0.157 | rest |
| 00:02:43 | -2.718 | rest |

| | | |
|---|---|---|
| 00:02:44 | 22.98 | loud |
| 00:02:45 | 53.557 | loud |
| 00:02:46 | 50.219 | loud |
| 00:02:47 | 48.405 | loud |
| 00:02:48 | 47.756 | loud |
| 00:02:49 | 1.629 | rest |
| 00:02:50 | 0.297 | rest |
| 00:02:51 | 0.096 | rest |
| 00:02:52 | 0.046 | rest |
| 00:02:53 | 0.027 | rest |
| 00:02:54 | 0.012 | rest |
| 00:02:55 | 0.024 | rest |
| 00:02:56 | 0.019 | rest |
| 00:02:57 | -1.764 | rest |
| 00:02:58 | 0.144 | rest |
| 00:02:59 | 0.064 | rest |
| 00:03:00 | -1.113 | rest |
| 00:03:01 | 0.606 | rest |
| 00:03:02 | 20.051 | glowing |
| 00:03:03 | 30.14 | glowing |
| 00:03:04 | 44.971 | glowing |
| 00:03:05 | 4.816 | glowing |
| 00:03:06 | 0.633 | rest |
| 00:03:07 | 0.115 | rest |
| 00:03:08 | 0.049 | rest |
| 00:03:09 | 0.035 | rest |
| 00:03:10 | 0.026 | rest |
| 00:03:11 | 0.022 | rest |
| 00:03:12 | 0.019 | rest |
| 00:03:13 | 0.017 | rest |

| | | |
|---|---|---|
| 00:03:14 | 0.027 | rest |
| 00:03:15 | 0.026 | rest |
| 00:03:16 | 0.022 | rest |
| 00:03:17 | -4.048 | rest |
| 00:03:18 | 1.934 | rest |
| 00:03:19 | 43.316 | sentence 2 |
| 00:03:20 | 35.249 | sentence 2 |
| 00:03:21 | 1.31 | rest |
| 00:03:22 | 0.179 | rest |
| 00:03:23 | 0.079 | rest |
| 00:03:24 | 0.034 | rest |
| 00:03:25 | 0.025 | rest |
| 00:03:26 | 0.019 | rest |
| 00:03:27 | 11.131 | sentence 3 |
| 00:03:28 | 39.416 | sentence 3 |
| 00:03:29 | 45.52 | sentence 3 |
| 00:03:30 | 2.133 | rest |
| 00:03:31 | 0.224 | rest |
| 00:03:32 | 0.071 | rest |
| 00:03:33 | 0.038 | rest |
| 00:03:34 | 0.028 | rest |
| 00:03:35 | -5.6 | rest |
| 00:03:36 | 48.794 | sentence 1 |
| 00:03:37 | 18.258 | sentence 1 |
| 00:03:38 | 42.952 | sentence 1 |
| 00:03:39 | 20.006 | sentence 1 |
| 00:03:40 | 0.113 | rest |
| 00:03:41 | 0.05 | rest |

***STL9***

| FLUKE time | mmHg | Condition |
|---|---|---|
| 00:00:00 | -0.002 | rest |
| 00:00:01 | 0.082 | rest |
| 00:00:02 | 0.066 | rest |
| 00:00:03 | -0.499 | rest |
| 00:00:04 | 0.647 | rest |
| 00:00:05 | 0.069 | rest |
| 00:00:06 | -0.097 | rest |
| 00:00:07 | -0.09 | rest |
| 00:00:08 | 0.105 | rest |
| 00:00:09 | 0.056 | rest |
| 00:00:10 | -0.036 | rest |
| 00:00:11 | 0.092 | rest |
| 00:00:12 | 0.055 | rest |
| 00:00:13 | 0.059 | rest |
| 00:00:14 | 0.066 | rest |
| 00:00:15 | -1.615 | rest |
| 00:00:16 | 20.564 | spontaneous |
| 00:00:17 | 9.951 | spontaneous |
| 00:00:18 | 23.445 | spontaneous |
| 00:00:19 | 21.236 | spontaneous |
| 00:00:20 | -2.196 | spontaneous |
| 00:00:21 | 20.162 | spontaneous |
| 00:00:22 | 20.064 | spontaneous |
| 00:00:23 | -0.966 | spontaneous |
| 00:00:24 | 19.681 | spontaneous |
| 00:00:25 | 2.455 | spontaneous |
| 00:00:26 | 23.195 | spontaneous |
| 00:00:27 | -0.174 | spontaneous |

| | | |
|---|---|---|
| 00:00:28 | 20.564 | spontaneous |
| 00:00:29 | 2.921 | spontaneous |
| 00:00:30 | 22.944 | spontaneous |
| 00:00:31 | 26.27 | spontaneous |
| 00:00:32 | 0.129 | rest |
| 00:00:33 | -0.057 | rest |
| 00:00:34 | 0.552 | rest |
| 00:00:35 | 18.39 | spontaneous |
| 00:00:36 | 0.236 | rest |
| 00:00:37 | 11.321 | spontaneous |
| 00:00:38 | 9.901 | spontaneous |
| 00:00:39 | 29.695 | spontaneous |
| 00:00:40 | -1.548 | spontaneous |
| 00:00:41 | 32.465 | spontaneous |
| 00:00:42 | -0.435 | spontaneous |
| 00:00:43 | 8.034 | spontaneous |
| 00:00:44 | -0.372 | spontaneous |
| 00:00:45 | 18.199 | spontaneous |
| 00:00:46 | 31.161 | spontaneous |
| 00:00:47 | 0.469 | rest |
| 00:00:48 | 0.097 | rest |
| 00:00:49 | 0.075 | rest |
| 00:00:50 | 0.087 | rest |
| 00:00:51 | 0.064 | rest |
| 00:00:52 | -0.807 | rest |
| 00:00:53 | 0.207 | rest |
| 00:00:54 | 0.076 | rest |
| 00:00:55 | -0.257 | rest |
| 00:00:56 | 1.012 | rest |
| 00:00:57 | 0.114 | rest |

| | | |
|---|---|---|
| 00:00:58 | 0.076 | rest |
| 00:00:59 | -1.358 | rest |
| 00:01:00 | -0.974 | rest |
| 00:01:01 | 0.061 | rest |
| 00:01:02 | 26.71 | comfortable a |
| 00:01:03 | 29.029 | comfortable a |
| 00:01:04 | 35.233 | comfortable a |
| 00:01:05 | 38.317 | comfortable a |
| 00:01:06 | 42.514 | comfortable a |
| 00:01:07 | 43.197 | comfortable a |
| 00:01:08 | 41.52 | comfortable a |
| 00:01:09 | 43.341 | comfortable a |
| 00:01:10 | 40.594 | comfortable a |
| 00:01:11 | -1.942 | rest |
| 00:01:12 | -0.828 | rest |
| 00:01:13 | 10.175 | rest |
| 00:01:14 | -0.107 | rest |
| 00:01:15 | -0.885 | rest |
| 00:01:16 | 1.086 | rest |
| 00:01:17 | 0.129 | rest |
| 00:01:18 | -2.805 | rest |
| 00:01:19 | -0.294 | rest |
| 00:01:20 | 18.324 | comfortable a |
| 00:01:21 | 22.377 | comfortable a |
| 00:01:22 | 23.361 | comfortable a |
| 00:01:23 | 23.779 | comfortable a |
| 00:01:24 | 25.587 | comfortable a |
| 00:01:25 | 25.651 | comfortable a |
| 00:01:26 | 26.063 | comfortable a |
| 00:01:27 | 26.585 | comfortable a |

| | | |
|---|---|---|
| 00:01:28 | 28.482 | comfortable a |
| 00:01:29 | 22.013 | comfortable a |
| 00:01:30 | 26.883 | comfortable a |
| 00:01:31 | -0.01 | rest |
| 00:01:32 | -0.595 | rest |
| 00:01:33 | 3.89 | swallow |
| 00:01:34 | 1.646 | swallow |
| 00:01:35 | -2.755 | rest |
| 00:01:36 | 0.306 | rest |
| 00:01:37 | -0.101 | rest |
| 00:01:38 | 0.086 | rest |
| 00:01:39 | 0.076 | rest |
| 00:01:40 | 0.066 | rest |
| 00:01:41 | 0.068 | rest |
| 00:01:42 | -1.153 | rest |
| 00:01:43 | 18.408 | spontaneous |
| 00:01:44 | 9.708 | spontaneous |
| 00:01:45 | 0.094 | rest |
| 00:01:46 | -0.036 | rest |
| 00:01:47 | -0.709 | rest |
| 00:01:48 | 20.396 | spontaneous |
| 00:01:49 | 1.298 | spontaneous |
| 00:01:50 | 19.418 | spontaneous |
| 00:01:51 | 0.882 | rest |
| 00:01:52 | -1.928 | rest |
| 00:01:53 | 0.684 | rest |
| 00:01:54 | 0.286 | rest |
| 00:01:55 | -1.221 | rest |
| 00:01:56 | 22.411 | low a |
| 00:01:57 | 24.718 | low a |

| | | |
|---|---|---|
| 00:01:58 | 22.944 | low a |
| 00:01:59 | 19.852 | low a |
| 00:02:00 | 0.986 | rest |
| 00:02:01 | -1.115 | rest |
| 00:02:02 | 1.19 | rest |
| 00:02:03 | 0.138 | rest |
| 00:02:04 | -2.145 | rest |
| 00:02:05 | 0.722 | rest |
| 00:02:06 | -1.988 | rest |
| 00:02:07 | -0.132 | rest |
| 00:02:08 | 13.849 | quiet a |
| 00:02:09 | 15.457 | quiet a |
| 00:02:10 | 14.208 | quiet a |
| 00:02:11 | 18.634 | quiet a |
| 00:02:12 | 18.313 | quiet a |
| 00:02:13 | 6.759 | quiet a |
| 00:02:14 | 0.101 | rest |
| 00:02:15 | 0.065 | rest |
| 00:02:16 | -1.157 | rest |
| 00:02:17 | -2.486 | rest |
| 00:02:18 | 8.688 | high a |
| 00:02:19 | 28.721 | high a |
| 00:02:20 | 34.038 | high a |
| 00:02:21 | 32.662 | high a |
| 00:02:22 | 33.358 | high a |
| 00:02:23 | 37.772 | high a |
| 00:02:24 | 0.394 | rest |
| 00:02:25 | 0.096 | rest |
| 00:02:26 | -0.765 | rest |
| 00:02:27 | 1.634 | rest |

| | | |
|---|---|---|
| 00:02:28 | 0.629 | rest |
| 00:02:29 | -6.263 | rest |
| 00:02:30 | 3.463 | rest |
| 00:02:31 | 62.164 | loud a |
| 00:02:32 | 66.43 | loud a |
| 00:02:33 | 70.642 | loud a |
| 00:02:34 | 9.197 | loud a |
| 00:02:35 | 0.284 | rest |
| 00:02:36 | 0.094 | rest |
| 00:02:37 | 0.071 | rest |
| 00:02:38 | 0.067 | rest |
| 00:02:39 | 0.072 | rest |
| 00:02:40 | -0.049 | rest |
| 00:02:41 | 0.655 | rest |
| 00:02:42 | 0.225 | rest |
| 00:02:43 | -3.05 | rest |
| 00:02:44 | 1.94 | rest |
| 00:02:45 | 0.905 | rest |
| 00:02:46 | -1.94 | rest |
| 00:02:47 | 0.44 | rest |
| 00:02:48 | 0.726 | rest |
| 00:02:49 | 0.067 | rest |
| 00:02:50 | 0.272 | rest |
| 00:02:51 | 0.6 | rest |
| 00:02:52 | -2.057 | rest |
| 00:02:53 | 13.3 | glowing preparation |
| 00:02:54 | 31.327 | glowing preparation |
| 00:02:55 | 45.769 | glowing preparation |
| 00:02:56 | 68.373 | glowing preparation |
| 00:02:57 | 98.032 | glowing preparation |

| | | |
|---|---|---|
| 00:02:58 | 0.239 | rest |
| 00:02:59 | -0.235 | rest |
| 00:03:00 | 9.78 | glowing |
| 00:03:01 | 10.789 | glowing |
| 00:03:02 | 4.893 | glowing |
| 00:03:03 | 3.357 | glowing |
| 00:03:04 | 0.578 | rest |
| 00:03:05 | 0.208 | rest |
| 00:03:06 | 0.305 | rest |
| 00:03:07 | 0.155 | rest |
| 00:03:08 | 0.035 | rest |
| 00:03:09 | 0.083 | rest |
| 00:03:10 | 0.078 | rest |
| 00:03:11 | -0.579 | rest |
| 00:03:12 | 1.274 | rest |
| 00:03:13 | -1.029 | rest |
| 00:03:14 | 28.702 | sentence 2 |
| 00:03:15 | 31.801 | sentence 2 |
| 00:03:16 | 27.361 | sentence 2 |
| 00:03:17 | 0.199 | rest |
| 00:03:18 | 0.082 | rest |
| 00:03:19 | 0.069 | rest |
| 00:03:20 | -4.298 | rest |
| 00:03:21 | 4.566 | rest |
| 00:03:22 | 24.601 | sentence 3 |
| 00:03:23 | 40.207 | sentence 3 |
| 00:03:24 | 39.505 | sentence 3 |
| 00:03:25 | 0.562 | rest |
| 00:03:26 | 0.099 | rest |
| 00:03:27 | 0.078 | rest |

| | | |
|---|---|---|
| 00:03:28 | -1.472 | rest |
| 00:03:29 | 31.972 | sentence 1 |
| 00:03:30 | 3.908 | sentence 1 |
| 00:03:31 | 24.918 | sentence 1 |
| 00:03:32 | 49.003 | sentence 1 |
| 00:03:33 | 68.756 | sentence 1 |
| 00:03:34 | -0.197 | rest |

***STL10***

| **FLUKE time** | **mmHg** | **Condition** |
|---|---|---|
| 00:00:00 | 0.142 | rest |
| 00:00:01 | 0.075 | rest |
| 00:00:02 | -0.33 | rest |
| 00:00:03 | -0.211 | rest |
| 00:00:04 | 0.264 | rest |
| 00:00:05 | -0.01 | rest |
| 00:00:06 | 0.054 | rest |
| 00:00:07 | 0.019 | rest |
| 00:00:08 | -1.009 | rest |
| 00:00:09 | -1.436 | rest |
| 00:00:10 | 11.421 | spontaneous |
| 00:00:11 | 17.329 | spontaneous |
| 00:00:12 | 0.259 | rest |
| 00:00:13 | -2.05 | rest |
| 00:00:14 | 20.071 | spontaneous |
| 00:00:15 | 3.091 | spontaneous |
| 00:00:16 | -1.707 | spontaneous |
| 00:00:17 | 20.478 | spontaneous |
| 00:00:18 | 3.759 | spontaneous |

| | | |
|---|---|---|
| 00:00:19 | 1.276 | spontaneous |
| 00:00:20 | 22.549 | spontaneous |
| 00:00:21 | -0.304 | spontaneous |
| 00:00:22 | 16.656 | spontaneous |
| 00:00:23 | 9.273 | spontaneous |
| 00:00:24 | 0.987 | spontaneous |
| 00:00:25 | 17.084 | spontaneous |
| 00:00:26 | 9.571 | spontaneous |
| 00:00:27 | 3.057 | spontaneous |
| 00:00:28 | 7.615 | spontaneous |
| 00:00:29 | -0.044 | spontaneous |
| 00:00:30 | -2.4 | spontaneous |
| 00:00:31 | 16.651 | spontaneous |
| 00:00:32 | 15.865 | spontaneous |
| 00:00:33 | -4.852 | spontaneous |
| 00:00:34 | 22.801 | spontaneous |
| 00:00:35 | 18.305 | spontaneous |
| 00:00:36 | 3.741 | spontaneous |
| 00:00:37 | 17.069 | spontaneous |
| 00:00:38 | 20.529 | spontaneous |
| 00:00:39 | 3.995 | spontaneous |
| 00:00:40 | 9.898 | spontaneous |
| 00:00:41 | 7.772 | spontaneous |
| 00:00:42 | -0.072 | spontaneous |
| 00:00:43 | -3.107 | spontaneous |
| 00:00:44 | 14.363 | spontaneous |
| 00:00:45 | 13.888 | spontaneous |
| 00:00:46 | 1.207 | rest |
| 00:00:47 | -1.812 | rest |
| 00:00:48 | -1.82 | rest |

| | | |
|---|---|---|
| 00:00:49 | 1.396 | rest |
| 00:00:50 | -0.591 | rest |
| 00:00:51 | 0.563 | rest |
| 00:00:52 | -2.067 | rest |
| 00:00:53 | -4.028 | rest |
| 00:00:54 | 0.039 | rest |
| 00:00:55 | 32.171 | comfortable a |
| 00:00:56 | 30.495 | comfortable a |
| 00:00:57 | 25.553 | comfortable a |
| 00:00:58 | 25.684 | comfortable a |
| 00:00:59 | 26.627 | comfortable a |
| 00:01:00 | 24.602 | comfortable a |
| 00:01:01 | 23.397 | comfortable a |
| 00:01:02 | 25.347 | comfortable a |
| 00:01:03 | 21.33 | comfortable a |
| 00:01:04 | 20.064 | comfortable a |
| 00:01:05 | 22.981 | comfortable a |
| 00:01:06 | 23.13 | comfortable a |
| 00:01:07 | 23.691 | comfortable a |
| 00:01:08 | 28.692 | comfortable a |
| 00:01:09 | 25.715 | comfortable a |
| 00:01:10 | 26.106 | comfortable a |
| 00:01:11 | 23.741 | comfortable a |
| 00:01:12 | 21.361 | comfortable a |
| 00:01:13 | 36.606 | comfortable a |
| 00:01:14 | 33.318 | comfortable a |
| 00:01:15 | 24.852 | comfortable a |
| 00:01:16 | 15.693 | comfortable a |
| 00:01:17 | 13.671 | comfortable a |
| 00:01:18 | -8.458 | rest |

| | | |
|---|---|---|
| 00:01:19 | 2.9 | rest |
| 00:01:20 | -1.366 | rest |
| 00:01:21 | -1.408 | rest |
| 00:01:22 | -0.595 | rest |
| 00:01:23 | 2.103 | rest |
| 00:01:24 | 0.596 | rest |
| 00:01:25 | -3.241 | rest |
| 00:01:26 | 1.621 | rest |
| 00:01:27 | -0.12 | rest |
| 00:01:28 | 1.078 | rest |
| 00:01:29 | -4.021 | rest |
| 00:01:30 | -13.323 | rest |
| 00:01:31 | 16.362 | comfortable a |
| 00:01:32 | 30.855 | comfortable a |
| 00:01:33 | 25.827 | comfortable a |
| 00:01:34 | 24.821 | comfortable a |
| 00:01:35 | 23.39 | comfortable a |
| 00:01:36 | 24.727 | comfortable a |
| 00:01:37 | 22.155 | comfortable a |
| 00:01:38 | 21.907 | comfortable a |
| 00:01:39 | 19.75 | comfortable a |
| 00:01:40 | 20.278 | comfortable a |
| 00:01:41 | 20.652 | comfortable a |
| 00:01:42 | 20.212 | comfortable a |
| 00:01:43 | 19.374 | comfortable a |
| 00:01:44 | 18.713 | comfortable a |
| 00:01:45 | 19.421 | comfortable a |
| 00:01:46 | 19.452 | comfortable a |
| 00:01:47 | 18.341 | comfortable a |

| | | |
|---|---|---|
| 00:01:48 | 18.303 | comfortable a |
| 00:01:49 | 17.191 | comfortable a |
| 00:01:50 | 17.549 | comfortable a |
| 00:01:51 | 17.418 | comfortable a |
| 00:01:52 | 18.185 | comfortable a |
| 00:01:53 | 17.864 | comfortable a |
| 00:01:54 | 17.629 | comfortable a |
| 00:01:55 | 18.016 | comfortable a |
| 00:01:56 | 19.652 | comfortable a |
| 00:01:57 | 23.574 | comfortable a |
| 00:01:58 | 19.751 | comfortable a |
| 00:01:59 | 18.658 | comfortable a |
| 00:02:00 | 9.739 | comfortable a |
| 00:02:01 | -3.121 | rest |
| 00:02:02 | -0.474 | rest |
| 00:02:03 | -0.464 | rest |
| 00:02:04 | 0.763 | rest |
| 00:02:05 | 2.36 | rest |
| 00:02:06 | -0.188 | rest |
| 00:02:07 | -2.003 | rest |
| 00:02:08 | 0.897 | rest |
| 00:02:09 | -0.221 | rest |
| 00:02:10 | 0.879 | rest |
| 00:02:11 | -0.076 | rest |
| 00:02:12 | -0.525 | rest |
| 00:02:13 | -1.545 | rest |
| 00:02:14 | 2.331 | rest |
| 00:02:15 | -1.118 | rest |
| 00:02:16 | 34.375 | low a |
| 00:02:17 | 29.41 | low a |

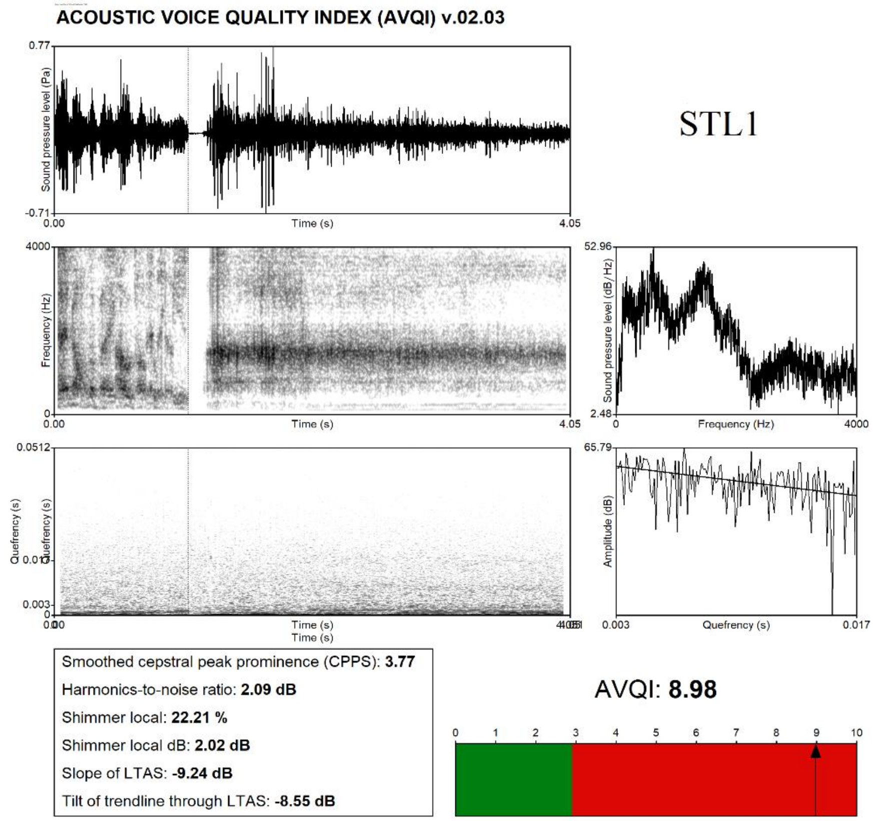
| | | |
|---|---|---|
| 00:02:18 | 32.123 | low a |
| 00:02:19 | 32.32 | low a |
| 00:02:20 | 31.197 | low a |
| 00:02:21 | 30.59 | low a |
| 00:02:22 | 31.183 | low a |
| 00:02:23 | 39.088 | low a |
| 00:02:24 | 23.134 | low a |
| 00:02:25 | 0.475 | rest |
| 00:02:26 | -5.082 | rest |
| 00:02:27 | 3.07 | rest |
| 00:02:28 | -1.1 | rest |
| 00:02:29 | 1.006 | rest |
| 00:02:30 | -0.059 | rest |
| 00:02:31 | -0.012 | rest |
| 00:02:32 | -1.199 | rest |
| 00:02:33 | -2.453 | rest |
| 00:02:34 | 12.52 | rest |
| 00:02:35 | 15.984 | quiet a |
| 00:02:36 | 14.053 | quiet a |
| 00:02:37 | 13.743 | quiet a |
| 00:02:38 | 14.328 | quiet a |
| 00:02:39 | 14.272 | quiet a |
| 00:02:40 | 14.891 | quiet a |
| 00:02:41 | 15.96 | quiet a |
| 00:02:42 | 13.514 | quiet a |
| 00:02:43 | 3.556 | rest |
| 00:02:44 | -1.126 | rest |
| 00:02:45 | 0.566 | rest |
| 00:02:46 | 0.046 | rest |
| 00:02:47 | 0.155 | rest |

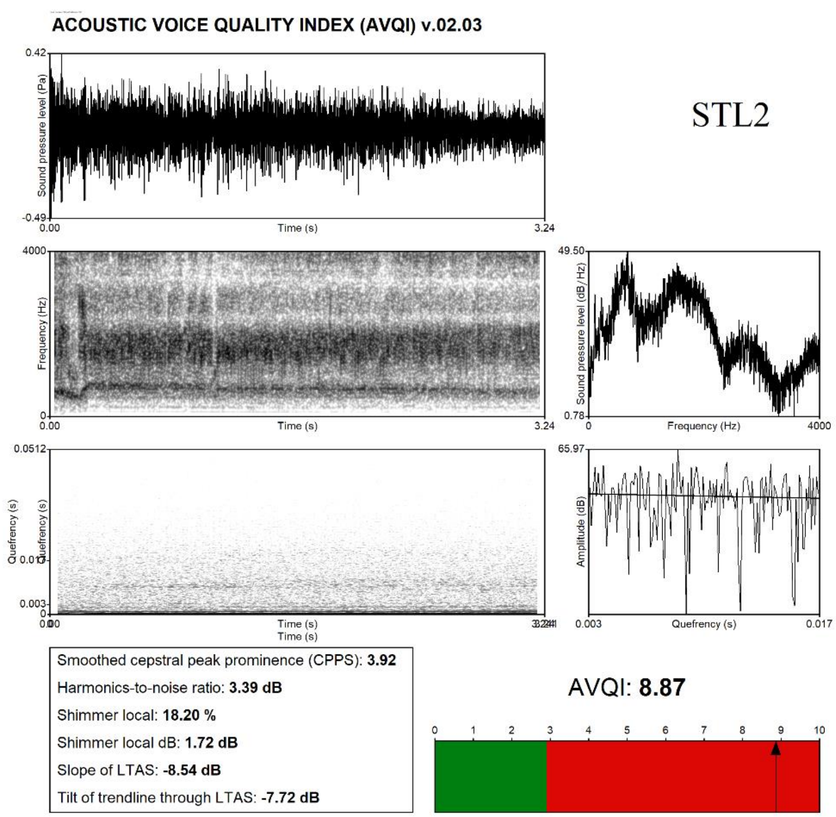
| | | |
|---|---|---|
| 00:02:48 | -1.228 | rest |
| 00:02:49 | 0.129 | rest |
| 00:02:50 | -1.322 | rest |
| 00:02:51 | 27.546 | high a |
| 00:02:52 | 27.444 | high a |
| 00:02:53 | 30.554 | high a |
| 00:02:54 | 30.497 | high a |
| 00:02:55 | 29.633 | high a |
| 00:02:56 | 22.73 | high a |
| 00:02:57 | 16.228 | high a |
| 00:02:58 | 1.752 | rest |
| 00:02:59 | -1.77 | rest |
| 00:03:00 | 0.383 | rest |
| 00:03:01 | -0.081 | rest |
| 00:03:02 | 0.019 | rest |
| 00:03:03 | 0.101 | rest |
| 00:03:04 | -0.519 | rest |
| 00:03:05 | 1.476 | rest |
| 00:03:06 | -8.035 | rest |
| 00:03:07 | 66.947 | loud a |
| 00:03:08 | 65.303 | loud a |
| 00:03:09 | 57.029 | loud a |
| 00:03:10 | 53.539 | loud a |
| 00:03:11 | 49.059 | loud a |
| 00:03:12 | 26 | loud a |
| 00:03:13 | -0.359 | rest |
| 00:03:14 | -1.772 | rest |
| 00:03:15 | 1.161 | rest |
| 00:03:16 | -0.163 | rest |
| 00:03:17 | 0.167 | rest |

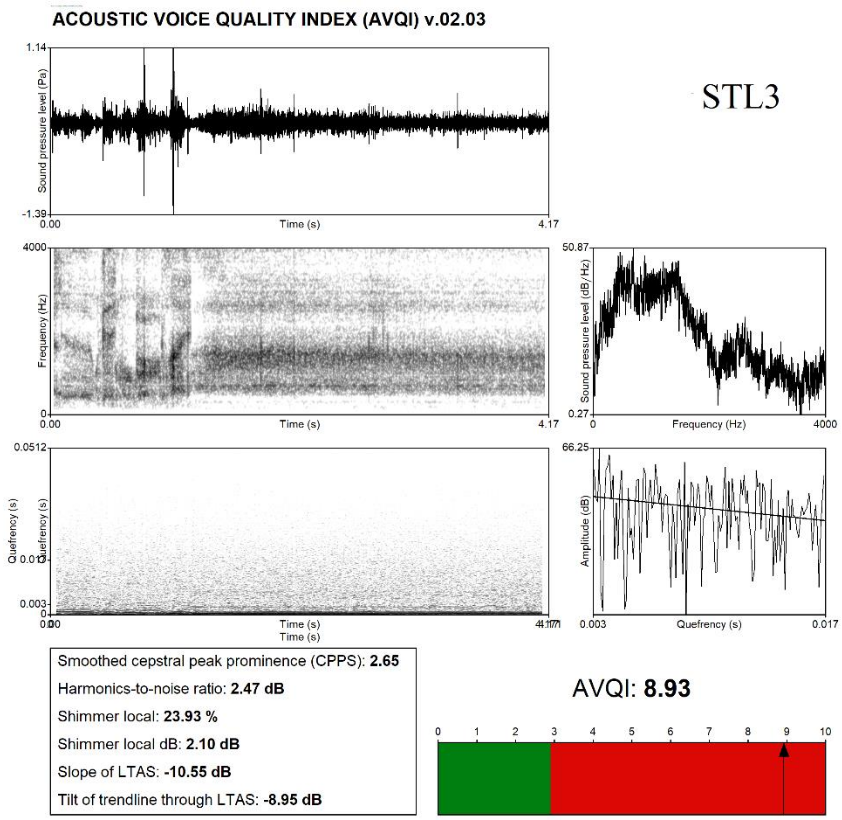
| | | |
|---|---|---|
| 00:03:18 | -1.284 | rest |
| 00:03:19 | -6.304 | rest |
| 00:03:20 | 24.143 | glowing |
| 00:03:21 | 30.627 | glowing |
| 00:03:22 | 4.76 | rest |
| 00:03:23 | 2.272 | rest |
| 00:03:24 | -0.124 | rest |
| 00:03:25 | -4.761 | rest |
| 00:03:26 | 37.709 | glowing |
| 00:03:27 | 37.996 | glowing |
| 00:03:28 | 9.177 | rest |
| 00:03:29 | 2.277 | rest |
| 00:03:30 | -2.067 | rest |
| 00:03:31 | 2.653 | rest |
| 00:03:32 | -1.253 | rest |
| 00:03:33 | 0.971 | rest |
| 00:03:34 | 0.131 | rest |
| 00:03:35 | 1.623 | rest |
| 00:03:36 | -1.883 | rest |
| 00:03:37 | -2.053 | rest |
| 00:03:38 | -0.162 | rest |
| 00:03:39 | 37.639 | sentence 2 |
| 00:03:40 | 39.625 | sentence 2 |
| 00:03:41 | 1.465 | rest |
| 00:03:42 | 0.321 | rest |
| 00:03:43 | -0.442 | rest |
| 00:03:44 | 0.168 | rest |
| 00:03:45 | -0.283 | rest |
| 00:03:46 | -1.536 | rest |
| 00:03:47 | 28.077 | sentence 3 |

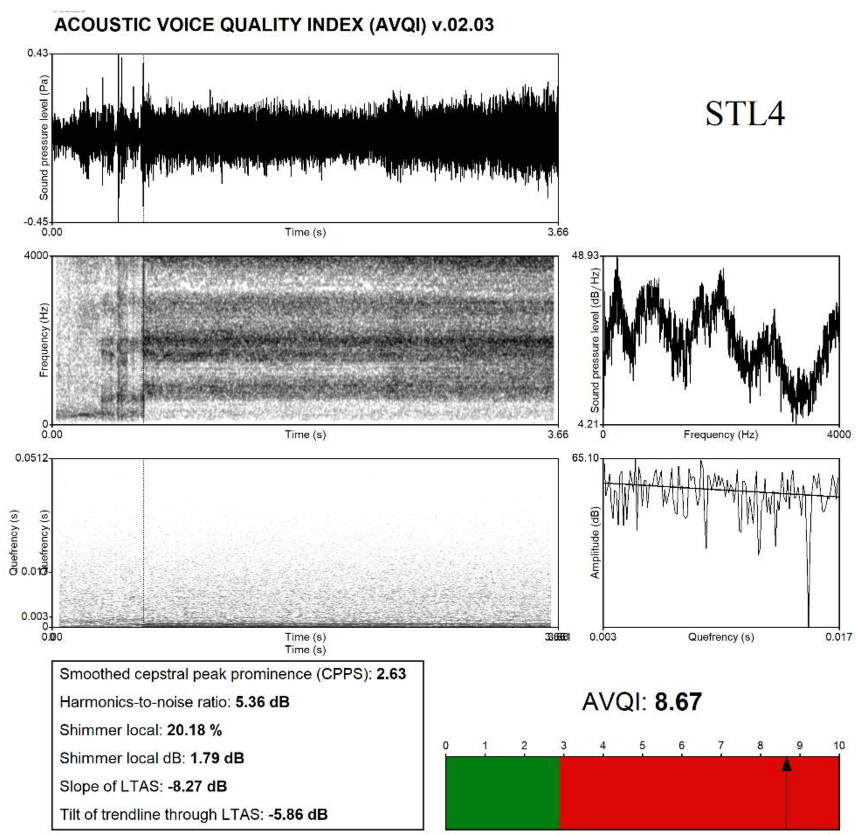
| | | |
|---|---|---|
| 00:03:48 | 29.904 | sentence 3 |
| 00:03:49 | 25.38 | sentence 3 |
| 00:03:50 | -0.242 | rest |
| 00:03:51 | -1.821 | rest |
| 00:03:52 | 0.88 | rest |
| 00:03:53 | 0.266 | rest |
| 00:03:54 | 0.124 | rest |
| 00:03:55 | 0.875 | rest |
| 00:03:56 | -0.781 | rest |
| 00:03:57 | 20.001 | rest |
| 00:03:58 | -4.354 | rest |
| 00:03:59 | 26.282 | sentence 1 |
| 00:04:00 | 30.523 | sentence 1 |
| 00:04:01 | 21.245 | sentence 1 |
| 00:04:02 | 0.136 | rest |
| 00:04:03 | 8.594 | spontaneous |
| 00:04:04 | 0.149 | rest |
| 00:04:05 | -2.117 | rest |
| 00:04:06 | -2.34 | rest |
| 00:04:07 | 19.957 | spontaneous |
| 00:04:08 | 1 | rest |
| 00:04:09 | -0.694 | rest |

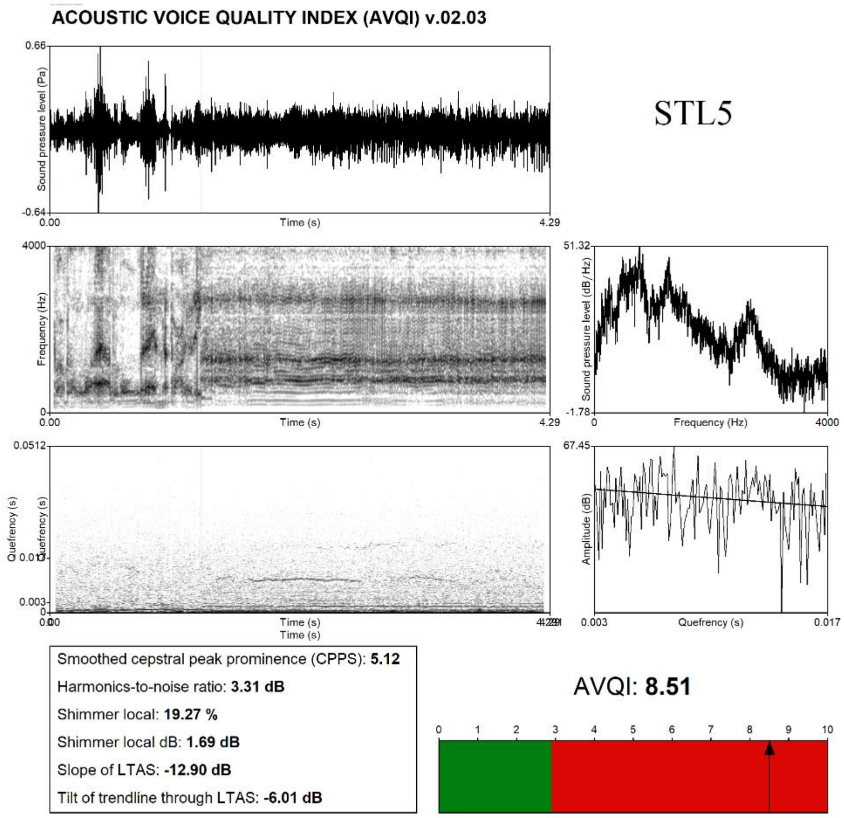
## Appendix IV: AVQI per participant

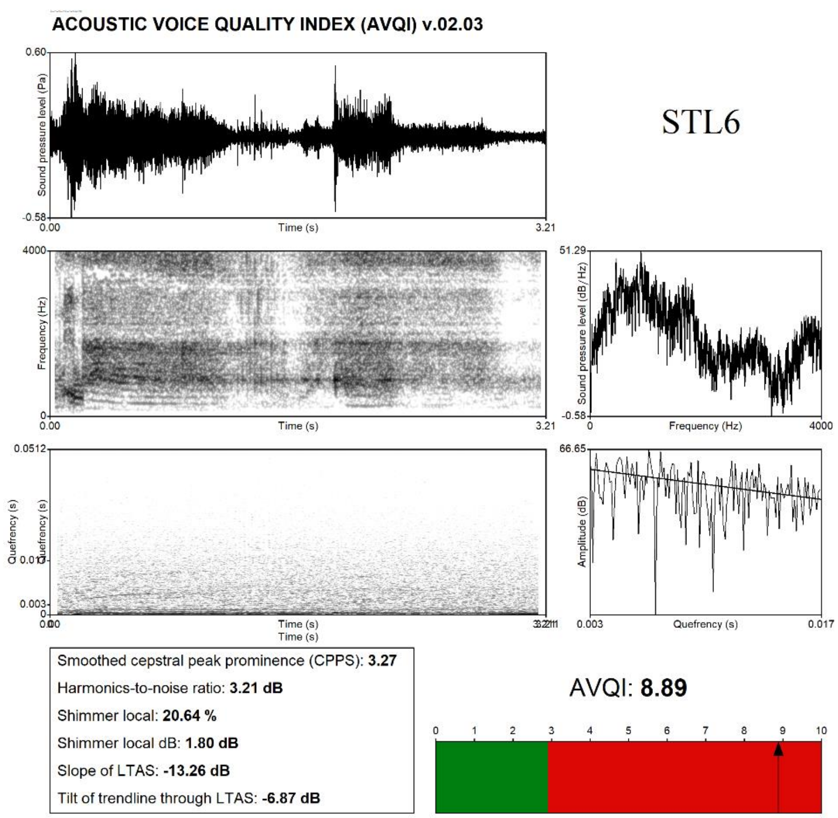


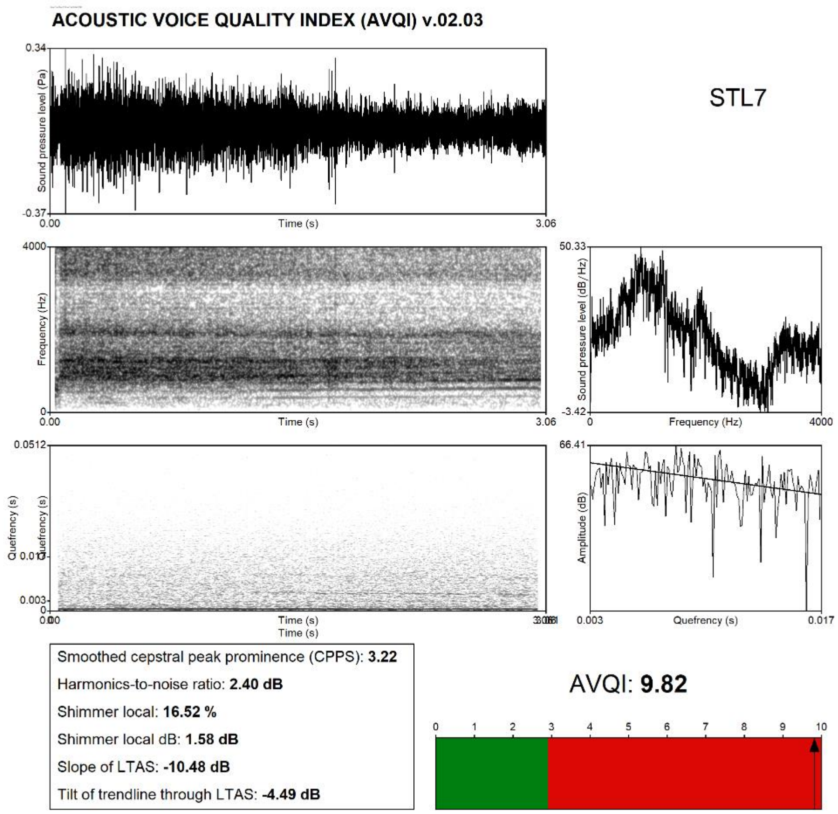



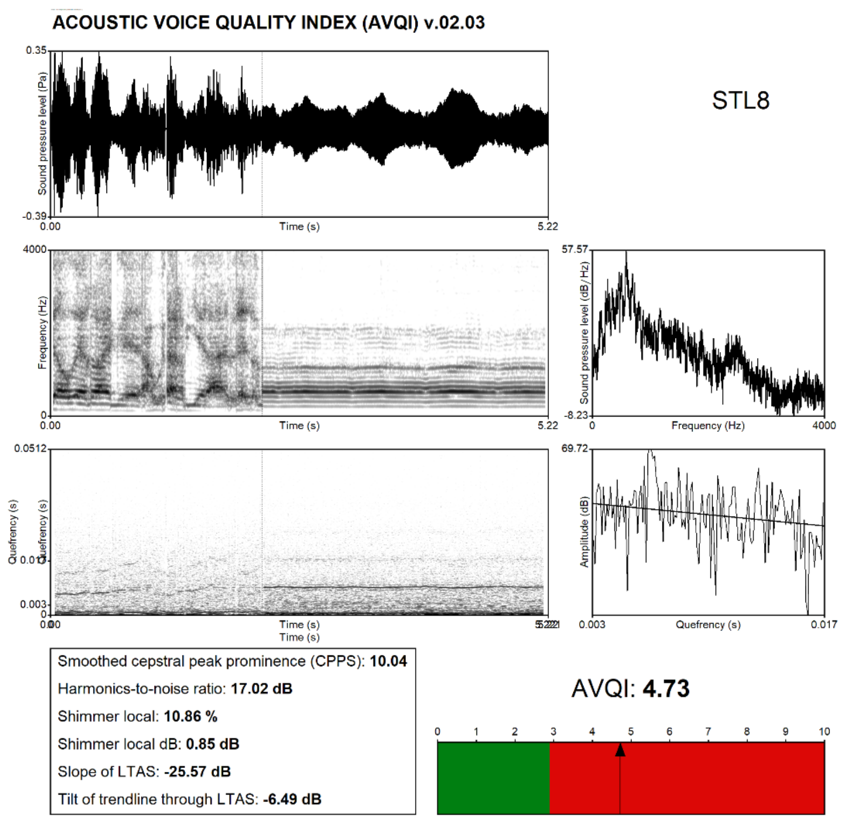

ACOUSTIC VOICE QUALITY INDEX (AVQI) v.02.03
STL3
Sound pressure level (Pa)
Time (s)
Frequency (Hz)
Sound pressure level (dB/Hz)
Quefrency (s)
Amplitude (dB)
Smoothed cepstral peak prominence (CPPS): 2.65
Harmonics-to-noise ratio: 2.47 dB
Shimmer local: 23.93 %
Shimmer local dB: 2.10 dB
Slope of LTAS: -10.55 dB
Tilt of trendline through LTAS: -8.95 dB
AVQI: 8.93


ACOUSTIC VOICE QUALITY INDEX (AVQI) v.02.03
STL4
Sound pressure level (Pa)
Time (s)
Frequency (Hz)
Sound pressure level (dB/Hz)
Quefrency (s)
Amplitude (dB)
Smoothed cepstral peak prominence (CPPS): 2.63
Harmonics-to-noise ratio: 5.36 dB
Shimmer local: 20.18 %
Shimmer local dB: 1.79 dB
Slope of LTAS: -8.27 dB
Tilt of trendline through LTAS: -5.86 dB
AVQI: 8.67

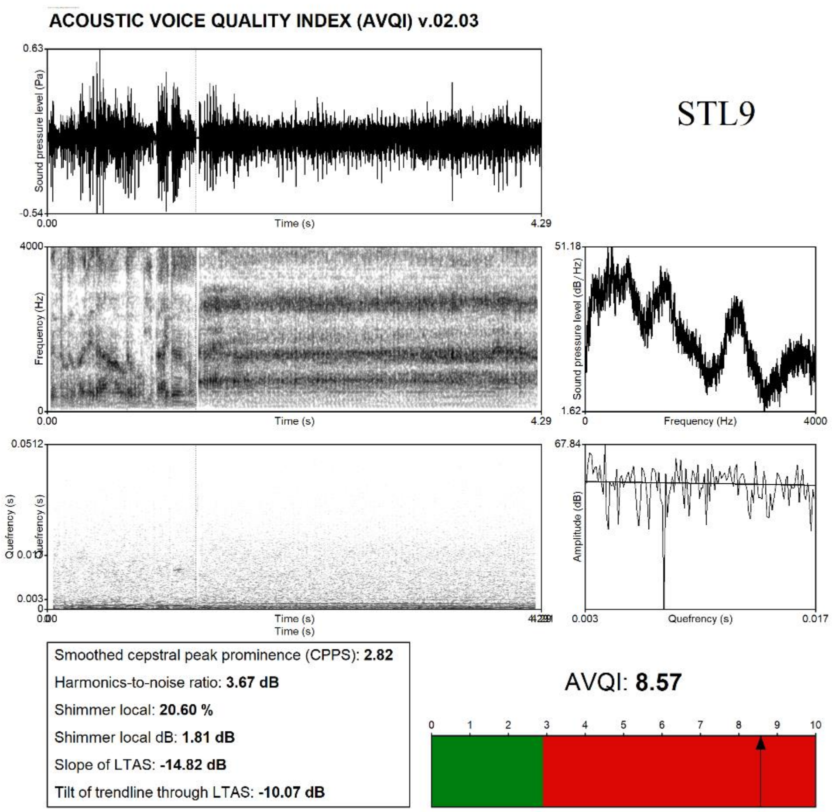

ACOUSTIC VOICE QUALITY INDEX (AVQI) v.02.03
STL5
Sound pressure level (Pa)
Time (s)
Frequency (Hz)
Sound pressure level (dB/Hz)
Quefrency (s)
Amplitude (dB)
Smoothed cepstral peak prominence (CPPS): 5.12
Harmonics-to-noise ratio: 3.31 dB
Shimmer local: 19.27 %
Shimmer local dB: 1.69 dB
Slope of LTAS: -12.90 dB
Tilt of trendline through LTAS: -6.01 dB
AVQI: 8.51


ACOUSTIC VOICE QUALITY INDEX (AVQI) v.02.03
STL6
Sound pressure level (Pa)
Time (s)
Frequency (Hz)
Sound pressure level (dB/Hz)
Quefrency (s)
Amplitude (dB)
Smoothed cepstral peak prominence (CPPS): 3.27
Harmonics-to-noise ratio: 3.21 dB
Shimmer local: 20.64 %
Shimmer local dB: 1.80 dB
Slope of LTAS: -13.26 dB
Tilt of trendline through LTAS: -6.87 dB
AVQI: 8.89

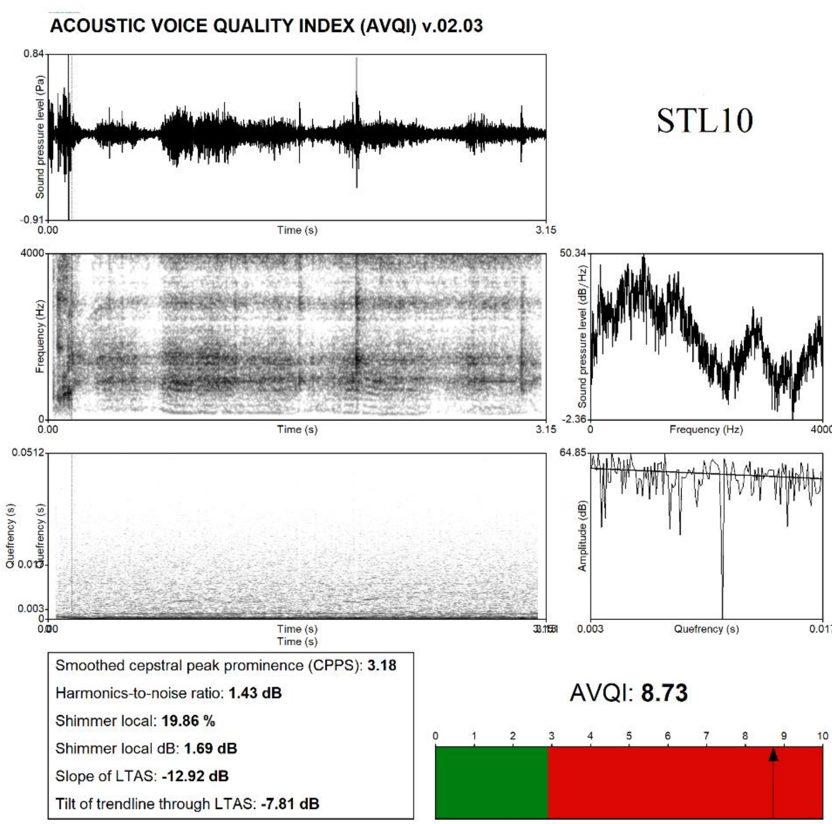

ACOUSTIC VOICE QUALITY INDEX (AVQI) v.02.03
STL7
Sound pressure level (Pa)
Time (s)
Frequency (Hz)
Quefrency (s)
Amplitude (dB)
Smoothed cepstral peak prominence (CPPS): 3.22
Harmonics-to-noise ratio: 2.40 dB
Shimmer local: 16.52 %
Shimmer local dB: 1.58 dB
Slope of LTAS: -10.48 dB
Tilt of trendline through LTAS: -4.49 dB
AVQI: 9.82


ACOUSTIC VOICE QUALITY INDEX (AVQI) v.02.03
STL8
Sound pressure level (Pa)
Time (s)
Frequency (Hz)
Quefrency (s)
Amplitude (dB)
Smoothed cepstral peak prominence (CPPS): 10.04
Harmonics-to-noise ratio: 17.02 dB
Shimmer local: 10.86 %
Shimmer local dB: 0.85 dB
Slope of LTAS: -25.57 dB
Tilt of trendline through LTAS: -6.49 dB
AVQI: 4.73

STL9


ACOUSTIC VOICE QUALITY INDEX (AVQI) v.02.03
Sound pressure level (Pa)
Time (s)
Frequency (Hz)
Sound pressure level (dB/ Hz)
Quefrency (s)
Amplitude (dB)
Smoothed cepstral peak prominence (CPPS): 2.82
Harmonics-to-noise ratio: 3.67 dB
Shimmer local: 20.60 %
Shimmer local dB: 1.81 dB
Slope of LTAS: -14.82 dB
Tilt of trendline through LTAS: -10.07 dB
AVQI: 8.57

STL10


ACOUSTIC VOICE QUALITY INDEX (AVQI) v.02.03
Sound pressure level (Pa)
Time (s)
Frequency (Hz)
Sound pressure level (dB/ Hz)
Quefrency (s)
Amplitude (dB)
Smoothed cepstral peak prominence (CPPS): 3.18
Harmonics-to-noise ratio: 1.43 dB
Shimmer local: 19.86 %
Shimmer local dB: 1.69 dB
Slope of LTAS: -12.92 dB
Tilt of trendline through LTAS: -7.81 dB
AVQI: 8.73

**Appendix V: VHI-10 score per participant**

| | VHI-10 score | VHI VAS (mm) | Voice rating |
|---|---|---|---|
| **STL1** | 12 | 91 | As usual |
| **STL2** | 26 | 49 | As usual |
| **STL3** | 26 | 48 | Better |
| **STL4** | 25 | 14 | As usual |
| **STL5** | 16 | 51 | As usual |
| **STL6** | 21 | 31 | As usual |
| **STL7** | 22 | 21 | Better |
| **STL8** | 18 | 58 | As usual |
| **STL9** | 15 | 75 | As usual |
| **STL10** | 20 | 30 | As usual |
| **Mean (SD)** | 20.10 (4.84) | 46.80 (23.97) | – |