

The tongue protrusion in post-mortem fire

Ilenia Bianchi¹, Martina Focardi¹, Valentina Bugelli¹, Barbara Gualco¹, Francesco Pradella¹, Vilma Pinchi¹

¹Department of Health Sciences, Section of Medical Forensic Sciences, University of Florence, Florence, Italy

Corresponding author:
martinafocardi@gmail.com

The authors declare that they have no conflict of interest.

KEYWORDS

Tongue protrusion
Burned
Post-mortem fire
Forensic odontologist

J Forensic Odontostomatol
2019. May;(37): 1-26:31
ISSN :2219-6749

ABSTRACT

Burned bodies raise relevant issues for forensic pathologist and odontologist both for the identification and the cause of death and possible vital burning.

The tongue protrusion is regularly investigated for the death caused by strangulation or hanging, whilst seems to be overlooked in case of charred remains as the significance of this sign is still discussed.

Different mechanisms are hypothesized in literature to explain the tongue protrusion both for vital and non-vital burning. This paper retrospectively evaluates some cases of carbonized corpses examined at the Forensic Pathology service of the University of Florence. The tongue protrusion shows a high occurrence both in vital (100%) and non-vital fires (66%). The involvement of a forensic odontologist in the cadaver examination result to be limited to one third of the cases. In two non-vital cases the tongue was described as protruded and clenched between the dental arches. The rigor of the genioglossus induced by the heat could explain the phenomenon. Further research on fire fatalities is required to analyze the tongue bleeding as a possible parameter to discriminate the vital by the non-vital tongue protrusion. Moreover, the mechanism at the origin of vital and non-vital tongue protrusion, the different position of the tongue (protruded from an open mouth, protruded and clenched between the dental arches, etc.) in different death circumstances, should be furtherly investigated with a meaningful collaboration between forensic pathologists and odontologists for a complete registration and interpretation of all the mouth originated evidence.

INTRODUCTION

Burned bodies are a real challenge for forensic pathologist and odontologist charged of the answer to the crucial question of the identification of the cause of death and possible ante-mortem (AM) exposition to the fire.^{1,2}

According to previous literature, the most reliable signs of vitality include soot deposits in the respiratory or digestive tract, a blood level of carboxi-hemoglobin (COHb) or HCN.³⁻⁶ An unclear or inconclusive evidence of vitality is present in some cases due to the specific dynamic of fire (e.g. "flashfire").

The tongue protrusion is regularly investigated in case of death caused by strangulation or hanging, but tends to be overlooked in case of charred remains as the significance of

this sign in the determination of the cause of death or burning vitality is still discussed. Bernitz reported a significant prevalence of tongue protrusion in cases of vital burning and concluded for the evidence of a correlation between the survival time and a protruded tongue.⁷ Hejna and Janik hypothesized the occurrence of a vital bleeding of the tongue⁸, actually described in different kind of death (hanging, strangulation and burning), as a possible explanation for the protrusion. Bohnert and Hejna discussed cases of protruded tongue in non-vital fire and outlined alternative mechanisms for the vital and post-mortem tongue protrusion following fire exposition.⁹ This paper retrospectively evaluates cases of charred bodies with tongue protrusion in case of vital or non-vital fire examined at the Forensic Pathology service of the University of Florence, Italy.

MATERIALS AND METHODS:

The sample consisted of thirty-four reports written by forensic pathologists charged by the Public Prosecutor to perform a judicial autopsy addressed to establish the cause of death and sometimes the identity of the subjects. No further documentation with the exception of the anonymous reports and the attached pictures was available to the authors and no further examinations were possibly obtained and conducted on the bodies other than those performed by the charged pathologists. The following data were collected from the reports examined:

- 1- age and gender of the individual
- 2- the extent of the burns (Table 1) that was assessed according to the Crow-Glassman Scale (CGS)
- 3- blood values of COHb and HCN
- 4- soot deposits in the respiratory or digestive tract
- 5- the involvement of a forensic odontologist in the case
- 6- the tongue protrusion

RESULTS

The age of the sample ranged from 5 to 90 years; the females individuals were 7 and the males 27. Of the 34 examined cases, only 11 reports included a detailed description of the tongue, whilst in 25 cases the tongue position was probably not detectable due to the severe destruction of the jaws or the tongue itself (e.g. charred bodies with open mouth).

The Tables 2-4 show the blood values of COHb, HCN and soot deposits in the digestive or respiratory tract in the cases with protruded tongue. Only in the 38% of the cases a forensic odontologist was involved in the examination. Even if the number of cases in which the position of the tongue was detectable or reported by the pathologist is small, the protrusion of the tongue was present in all the vital burnings; two in three post-mortem fire cases presented tongue protrusion. Hence, the tongue protrusion shows a high occurrence both in vital (100%) and non-vital fires (66%) in our limited sample.

Two badly burned cadavers were found in the ground after a post-mortem fire caused by an helicopter accident. The male bodies were identified as the pilot and passenger, respectively 61 and 54 years old. During the autopsy the forensic pathologist found severe traumatic lesions in both bodies (fractures of vertebrae, ribs, skull base, long bones, etc), and the tear of the aorta thoracic and abdominal tract respectively. The forensic pathologist concluded for immediate death following the precipitation. In both cases the tongue was described as protruded and clenched between the dental arches. The values of COHb and HCN were negative and no soots deposit were found in the respiratory or digestive tract. As shown in Table 1, both cadavers presented extended burns (CGS 4).

Table 1: Crow-Glassman Scale (CGS)

CGS-1	Death by inhalation of toxic fumes. First and second degree burns on the body. Visual identification is still possible.
CGS-2	Significant carbonization of the body. Possible mutilation of small bones of the hands and feet. Identification can be performed through dental records and /or DNA .
CGS-3	Significant carbonization of the body, with the skull still intact. Possible mutilation also of the limb bones. Possible identification through dental records and /or DNA.
CGS-4	Total fragmentation of the skull and further mutilation of the limb bones. Possible identification through dental records and /or DNA.
CGS-5	Skeletal remains. There are no remaining soft tissues and any remaining skeletal component is fragmented. The identification of the remains is highly problematic.

Table 2: Frequence of the tongue, vital signs, CGS and the intervention of a FOD

	Tongue protrusion	No tongue protrusion	Tongue position not detectable
Soot deposits	6	/	16
No soot deposits	4	1	5
COHb <10%	5	1	16
COHb >10%	5	/	7
CGS 1-2	2	1	9
CGS 3-5	8	/	14
Intervention of the forensic odontologist (FOD)	4	/	9

Table 3: Fire-fatalities. Correlation between tongue protrusion and cause of death

Death due to:	Tongue protrusion	No tongue protrusion	Tongue position not detectable
COHb			
- open place	/	/	/
- closed place	2	/	II
HCN			
- open place	/	/	/
- closed place	I	/	I
COHb and HCN	I	/	2
Fire- high temperature	4	/	4
Multiple factors	2	I	5

DISCUSSION

The tongue protrusion is a common finding in some deaths for asphyxiation (e.g., hanging, incomplete strangulation), and the compression of neck tissues and vessels is considered the cause of the phenomenon. A protruded tongue, clenched between the dental arches, can be frequently observed also in carbonized cadavers and the question if this sign could be considered an useful hint for the discrimination of vital and non-vital burning is still an unresolved matter of discussion in the Literature.⁷⁻¹¹ Different mechanisms have been hypothesized as the cause for the lingual protrusion in vital burning and post-mortem fire cases.

Bernitz found a correlation between the tongue protrusion and the occurrence of a vital burning.⁷ According to his causal hypothesis, the protrusion is attributed to the laryngospasm caused by a temperature higher than 150 °C and hyperventilation. Nikolic criticised Bernitz's conclusions saying that they were based on an incorrect statistical analysis and found a tongue protrusion in two post-mortem burning cases.

Bohnert and Hejna found that the tongue protrusion is not correlated to vital burning or heat-induced shrinkage of the cervical soft tissue.⁹ Different mechanics have been proposed to explain tongue protrusion in fire fatalities, among which the heat-induced shrinkage of cervical tissues, the heat-related vapor pressure,¹⁰ focal hemorrhage and interstitial edema of the lingual

tissues,⁸ or the rigor of the genioglossus muscle caused by the high temperature.¹¹

Some authors [Ishikawa et al 2018, Hashimoto et al 2003 and Quan et al 2003] focused their attention on the intramuscular bleeding at the tongue base of charred cadavers [ImBT]: the proposed mechanic is linked to the cervical compression caused by an incomplete occlusion of the carotids, cranial venous stasis, spasm of the lingual muscles and hypertensive agony that would cause the intramuscular bleeding of the tongue, similarly to what happens in some asphyctic deaths (e.g., incomplete, manual and ligature strangulation). Hashimoto and Ishikawa reported intramuscular bleeding of the tongue in vital fire cases with low levels of COHb and severe charring of the body. In cases with insufficient blood level of COHb the proposed cause of death was the extensive carbonization of the cervical tissues that dramatically harden and compress the neck quite similarly to what happens in the abovementioned asphyctic deaths (e.g., strangulation). This could explain the occurrence of the intramuscular bleeding reported in some vital carbonization cases.¹²⁻¹⁴

Because of the retrospective nature of the present study, the report is limited to 10 cases of tongue protrusion. Despite the small number of our sample, the occurrence of tongue protrusion was observed in all the cases of vital burning and in two of three cases of post-mortem fire. Unfortunately, in some of our cases the position of the tongue was not reported by the forensic

pathologist in charge of the autopsy and the involvement of a forensic odontologist is limited to very few cases. A collaboration between the forensic pathologist and an odontologist would have perhaps resulted in a most appropriate attention to the mouth not only for identification issues^{15,16} but also for the possible contribution that the oral findings can give to the ascertainment of the cause of the death.

In the two cases of non-vital fire, the levels of COHb (less than 2%) and HCN were negative, no soot deposits were found and the presence of aortic and skull lesions, led to conclude for a death immediately following the helicopter crash. The carbonization of two bodies was extensive, the facial and neck tissue were severely destroyed by the fire, the tongue hemorrhage was not investigated during autopsy. Anyway, we can suppose that it would be likely absent, since the tongue bleeding requires an hypertensive agony and a vital burning that were excluded in the described cases. Among the different mechanic described in the literature as a cause of tongue protrusion in the perimortem period, mostly related to asphyctic deaths or vital burning, only the heat-induced retraction of the cervical tissues and the lowering of the mandible, seem to be considered in these two non-vital burning cases. Nikolic, in two post-mortem burning cases, described¹¹ a heat rigor in the cervical region as it occurs in the rest of the body due to the shortening of muscles and tendons, that causes relevant modifications of the position of the body (e.g., pugilistic position). The protrusion of the tongue is considered as a sort of lingual rigor due to the heat that causes a shortening of the genioglossus which, in a condition similar to a physiological activation, produce the thrust of the tongue out of the mouth.

CONCLUSION

A tongue protrusion is observed and reported in different types of death. Generally speaking, the position and modifications (especially bleeding) of the tongue are deeply investigated in asphyctic deaths (hanging, strangulation, etc), whilst these conditions are not so considered in fire casualties. A long discussion stands in the literature between authors that believe that the protrusion of the tongue can be considered an useful sign of vitality during a fire and those who criticized this assumption.

Our study is based on a limited number of cases, but reveals the occurrence of a protruded tongue in all the cases of vital fire, but also in two thirds of non vital fire, emerging as an aspecific sign possibly correlated with exposition to high heat regardless of its ante or post-mortem occurrence. The mechanics of the lingual protrusion in vital and non-vital burning is still a matter of discussion. In cases of tongue protrusion in vital burning with lower COH levels similar mechanisms as in some types of asphyctic deaths are hypothesized to occur. In cases of non vital tongue protrusion a heat induced rigor of the genioglossus could explain the phenomenon. Further research on fire fatalities is required to analyze the tongue bleeding as a possible parameter to discriminate the vital by the non-vital tongue protrusion¹². Moreover, the mechanism at the origin of vital and non-vital tongue protrusion, the different position of the tongue (protruded from an open mouth, protruded and clenched between the dental arches, etc.) in different death circumstances, should be furtherly investigated with a meaningful collaboration between forensic pathologists and odontologists for a complete registration and interpretation of all the mouth originated evidence.

REFERENCES

1. Bugelli V, Papi L, Fornaro S, Stefanelli F, Chericoni S, Giusiani M, Vanin S, Campobasso CP. Entomotoxicology in burnt bodies: a case of maternal filicide-suicide by fire. *Int J Legal Med.* 2017 Sep;131(5):1299-1306. doi: 10.1007/s00414-017-1628-0. Epub 2017 Jul 9.
2. Focardi M, Defraia B, Bugelli V. An Unusual Case of Postmortem Burning Following Suicide. *J For Res.* 2019; 10:1 DOI: 10.4172/2157-7145.1000432
3. Bohnert M, Werner CR, Pollak S. Problems associated with the diagnosis of vitality in burned bodies. *Forensic Sci Int.* 2003 Aug 27; 135(3):197-205.
4. Yeoh MJ, Braitberg G. Carbon monoxide and cyanide poisoning in fire related death in Victoria, Australia. *J Toxicol Clin Toxicol.* 2004; 42(6):855-63.
5. Yoshida M, Adachi J, Watabiki T, Tatsuno Y, Ishida N. A study on house fire victims: Age, carboxyhemoglobin, hydrogen cyanide and hemolysis. *Forensic Sci Int.* 1991 Dec; 52(1):13-20.
6. Stamyk K, Thelander G, Ernstgard L, Ahlner J, Johanson G. Swedish forensic data 1992-2009 suggest hydrogen cyanide as an important cause of death in fire victims. *Inhal Toxicol.* 2012 Feb; 24(3):194-9. doi: 10.3109/08958378.2012.660285.
7. Bernitz H, Van Staden PJ, Cronjé CM, Sutherland R. Tongue protrusion as an indicator of vital burning. *Int J Legal Med.* 2014 Mar; 128(2):309-12. doi: 10.1007/s00414-013-0861-4. Epub 2013 Apr 23.
8. Hejna P, Janík M. Comments on tongue protrusion as an indicator of vital burning. *Int J Legal Med.* 2014 Mar; 128(2):321-2. doi: 10.1007/s00414-013-0931-7. Epub 2013 Oct 31.
9. Bonhert M, Hejna P. Tongue protrusion in burned bodies. *Int J Legal Med.* 2016 Sep; 130(5):1253-5. doi: 10.1007/s00414-016-1357-9. Epub 2016 Mar 17.
10. Madea B, Doberentz E. Protrusion of the tongue in burned bodies as a vital sign? Letter to the editor concerning the paper "Tongue protrusion as an indicator of vital burning" by Bernitz et al. *Int J Legal Med.* 2015 Mar; 129(2):313-4. doi: 10.1007/s00414-014-1019-8. Epub 2014 May 15.
11. Nikolic S, Zivkovic V. Protrusion of the tongue in bodies burned after death: two cases of arson to cover homicide. *Med Sci Law.* 2015 Oct ;55(4):300-3. doi: 10.1177/0025802414542260. Epub 2014 Jul 9.
12. Ishikawa N, Takaso M, Akasaka Y, Yamamoto H, Ikegaya H. The relationship between the intramuscular bleeding of the tongue and cause of death. *J Forensic Leg Med.* 2018 Oct; 59:50-55. doi: 10.1016/j.jflm.2018.08.001. Epub 2018 Aug 8.
13. Hashimoto Y, Moriya F, Nakanishi A. Intramuscular bleeding of the tongue in the victims of house fire. *Leg Med (Tokyo).* 2003 Mar; 5 Suppl 1:S328-31.
14. Quan L, Zhu BL, Ishida K, Oritani S, Taniguchi M, Kamikodai Y, Tsuda K, Fujita MQ, Maeda H. Hemorrhages in the root of the tongue in fire fatalities: the incidence and diagnostic value. *Leg Med (Tokyo).* 2003 Mar; 5 Suppl 1:S332-4.
15. Pinchi V, Bartolini V, Bertol E, Focardi M, Mari F, Ricci U, Vanin S, Norelli GA. Multiple deaths caused by a fire in a factory: identification and investigative issues. *J Forensic Odontostomatol.* 2016 Dec 1; 2(34): 47-59.
16. Ricci U, Carboni I, Iozzi S, Nutini AL, Contini E, Torricelli F, Focardi M, Pinchi V, Mari F, Norelli GA. Genetic identification of burned corpses as a part of disaster victim identification effort. *Forensic Sci Int: Genet Suppl Series.* 2015; 5, pp. e447-e448. doi: 10.1016/j.fsigss.2015.09.177