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Autopsy and Identification Techniques

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*“The whole of science is nothing more than a refinement of everyday thinking”
Albert Einstein (1879 – 1955)*

1. Introduction

Autopsy – different steps

1.1 Introduction – the Belgian DVI team

To illustrate the different activities of the reconstructive identification process of the Tsunami victims, we refer to the activities of the Belgian Disaster Victim Identification (DVI) Team, working at “Wat Yan Yao” (Buddhist temple in Takuapa village, near Khao Lak beach, Phang-Nga province) as part of the world wide DVI community which brought assistance to the Thai government (see Fig. 1, 2 and 3).



Fig. 1. General view of the disaster (Phang-Nga province).



Fig. 2. Wat Yan Yao Site 1a – Khao Lak: the entry to buddish temple.



Fig. 3. The pictures: exposition of the decedents.

For a proper post mortem (PM) examination and from a logistic point of view, it is recommended that a DVI team be multidisciplinary so that, immediately after deployment and regardless of local conditions and facilities, it can operate autonomously. This requires not only the presence of specialized forensic experts on the team but also a strong added

value of auxiliary personnel. The Belgian DVI team is composed of (i) policemen specialized in recovery/ exhumation, logistics and/ or administration, scientific laboratory and photography, (ii) forensic medical examiners (ideally with forensic anthropology specialization), (iii) forensic odontologists, (iv) civil protection members for body handling, transport, and assisting with the use of heavy equipment or machinery, (v) a psychologist trained in Post Traumatic Stress and available for the team all times, (vi) and a medical doctor and registered nurse attending to all team members’ medical needs. We recently published this organization in Table 1.

	1 Team leader	
	1 assistant team leader	
	1 logistics member	
	1 AM and Identification coordinator	
	1 Officer for international Management Center	
	1 Medical doctor	
	1 paramedical member (nurse)	
	1 psychologist	
PM line 1		PM line 2
1 chief line officer		1 chief line officer
1 pathologist + 1 DVI policeman (to help write documents and reports)		1 pathologist + 1 DVI policeman (to help write documents and reports)
1 odontologist + 1 DVI policeman (to help write documents and reports)		1 odontologist + 1 DVI policeman (help in writing documents and reports)
1 science laboratory policeman (for fingerprinting)		1 science laboratory policeman (for fingerprinting)
1 DVI policeman (for washing and identifying clothing, documents, jewelry...)		1 DVI policeman (for washing and identifying clothing, documents, jewelry...)
1 DVI policeman for completing PM Interpol documents		1 DVI policeman for completing PM Interpol documents
1 Belgian Civil protection member		1 Belgian Civil protection member
	1 DVI photographer	
	1 DVI member for collecting all information/ documents/ samples on final desk	

Table 1. Belgian DVI Team deployment (Beauthier et al., 2009).

Ideally, such kind of PM DVI team will be self-supporting and can be operational within a few hours after arrival at a mass disaster scene.

Note that - in theory - the collection of ante mortem (AM) material is classically handled by police officers, medical examiners and forensic odontologists who try to obtain informations from the missing person's families and practitioners. The AM DVI team is usually composed of 5 policemen, but also includes Red Cross members, psychologists and social assistants.

The first Belgian DVI Team arrived in Phuket on January 2, 2005 and a second one followed two weeks later after the first team returned home. A few team members worked during several months in data base organization at the Thai Tsunami Victim Identification Information Management Centre (TTVI-IMC) in Phuket.

1.2 External examination

1.2.1 Recovery

The recovery of the bodies was carried out by the local Thai population prior to the time of the international teams' arrival in Thailand (Fig. 4).



Fig. 4. Wat Yan Yao Site 1a – Khao Lak: innumerable bodies protected by dry ice (before autopsy).

The bodies were stored at Wat Yan Yao (Site 1A) for the identification process to start. After the first logistic problems were solved (Fig. 5) – electricity and water supply, airconditioning, protected space for the autopsy room – the PM identification line was divided into four work sections: fingerprinting, medical examination, odontology examination and DNA sampling (Fig. 6).



Fig. 5. Wat Yan Yao Site 1a – Khao Lak: first examinations’ activities.

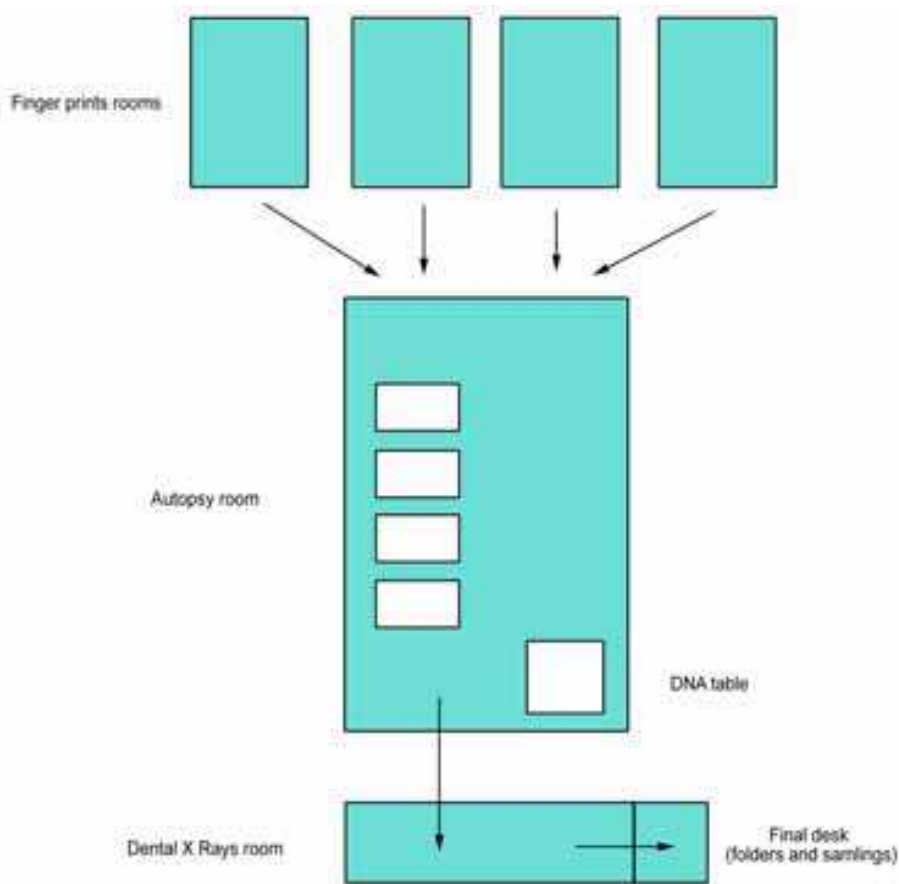


Fig. 6. Organization of the activities (first autopsy room).

1.2.2 Fingerprinting

Fingerprinting was very difficult due to the condition of the bodies but was successfully realized by specialists of the technical and scientific laboratories of the different national law enforcement agencies. Finger skin was removed by “degloving” and placed on the fingertip of one of the two operators. After powdering, the fingerprints were then transposed onto paper (Fig. 7). The use of separated fingerprinting rooms proved to be very practical and useful.



Fig. 7. Fingerprinting technique: “degloving” and “glove-on” method.

1.2.3 Autopsy room

After fingerprinting the body was transferred to the autopsy room, where external and internal descriptions took place (Fig. 8 and 9).

Clothing, jewelry and other personal belongings were systematically cleaned, described and photographed (with a metric scale and the corresponding body number in place) (Fig. 10).

The external body examination allowed (i) stature determination; (ii) description of tattoos, scars, anatomical and/ or sequel characteristics, congenital abnormalities, recent or old traumatic elements; (iii) phenotypic characteristics (e.g. cranial hair color and thoracic-, axillar-, arm- and pubic hair description...).



Fig. 8. First autopsy room.



Fig. 9. Second autopsy room.



Fig. 10. Clothes.

1.3 Internal examination

According to international agreements and recommendations decided at the staff meetings, the internal autopsy in Thailand was limited to the abdominal cavity, checking for the presence/ absence of the gall bladder, appendix, genitalia, etc.

Noted abnormal anatomic findings were subjected to a more extensive examination (e.g. dissection of a uterine tumor, description of tubar clips, intra-uterine devices, etc.) and description.

We estimate the necessity of an initial X-ray study, which was not realized during our Thai activities.

1.4 Facial dissection and interest of mandibular approach

To facilitate the work of the odontologists during the further part of the autopsy, it was essential to create a mandibular access.

We used a dissecting technique by making a semicircular incision, from ear to ear, behind each mandibular angle and passing through the anterior cervical region, under the submental area [modification of the Keiser-Nielsen method (Keiser-Nielsen, 1980)] (Fig. 11).

The cutaneous flap was inclined upwards to the face by using a Senn-Miller retractor allowing the exposure of the temporomandibular joints.

A second incision was made along the internal border of the mandibular body, cutting the muscles of the buccal floor, making it possible to release the lingual block (Fig. 12).

The muscles were sectioned on the mandible (*mandibula*). The *m. masseter* was cut at the level of the goniac angle and the *corpus mandibulae* (Fig. 13).

The *m. temporalis* was sectioned at the *processus coronoideus* of the mandible (Fig. 14), while the *mm. pterygoidei* were progressively dissected with the blade of the scalpel following the articular structures, when the mandible was separated at the level of the temporomandibular joint (Fig. 15).

The mandible was thus completely released (Fig. 16), without any destruction, allowing an easy repositioning in order to obtain a complete correct facial reconstruction (Beauthier et al., 2009).



Fig. 11. Mandibular dissection, first step: cutaneous incisions.



Fig. 12. Mandibular dissection, second step: buccal floor section along the inner border of *mandibula*.



Fig. 13. Mandibular dissection, third step: facial cutaneous flap and section of masticator muscles (*m. masseter*).



Fig. 14. Mandibular dissection, fourth step: complete cranial evidence of the *mandibula*.



Fig. 15. Mandibular dissection, fifth step: lateral aspect of the mandibular condyle and coronoid section of the *m. temporalis*.



Fig. 16. Mandibular dissection, sixth step: complete disarticulation of the temporomandibular joint and muscles sections along the medial border of *mandibula* (left and right dissections) which can be deposited.

1.5 Odontological examination

This anatomical technique facilitated the forensic odontologist's PM work, with an easy access to both the maxillar and mandibular dentition (Fig. 17). Separate pictures were taken of the upper and lower jaws and teeth in occlusal position, as well as with articulating jaws (Fig. 18). The complete dentition was described using Interpol protocols, nomenclature and forms (Bajaj, 2005; Sweet, 2006) (sound teeth, pathological teeth, restored teeth, absent AM or PM teeth, attrition and oral anatomical abnormalities) (Fig. 19).



Fig. 17. Dental first examination.

All the observations were carefully registered on pages F1 & F2 and marked on the odontogram of the PM pink form¹.

The body was then transferred to the next room, where dental radiographies were carried out (bite wing radiographies, specific X-rays related to dental particularities) (Fig. 20). During the initial weeks only conventional dental X-ray equipment was present, but in a later stage a Nomad™ handheld digital dental X-ray machine was made available, facilitating the odontologist's task for X-raying considerably.

The PM work was very intense, both the number of victims and the time restrictions for PM examination, allowing only 20 min for each work section: fingerprinting, medical examination, odontological examination.

¹ Accessible on the Interpol Internet website.

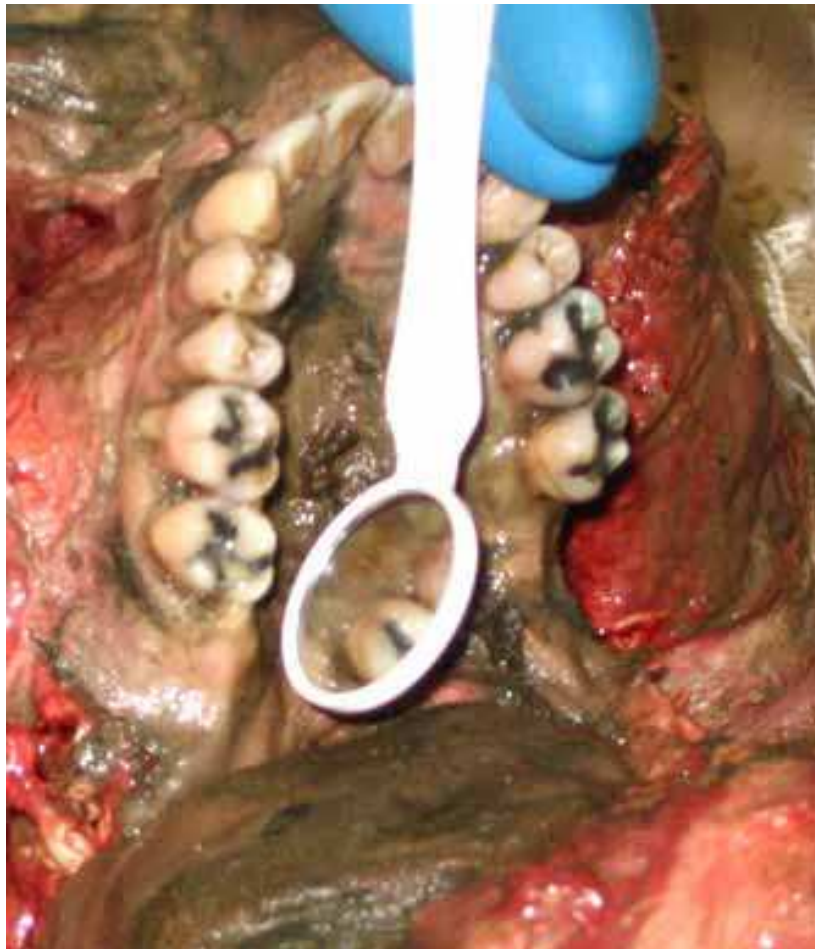


Fig. 18. Dental details.



Fig. 19. Particularities – *torus mandibularis*.



Fig. 20. Dental X-ray examination.

1.6 Reconstruction post autopsy

The particular dissection technique we explained enables also an easy reconstitution of the person's face by simply folding back the cutaneous facial tissues. This allows an eventual recognition of the victim by family members in a post identification stage if requested.

1.7 Particular considerations

Depending on the kind of PM examinations to be performed on the bodies, it might be very useful to conduct the medico-legal and anthropological examinations as near to the disaster site as possible. This helps to avoid destruction or loss of evidence caused by body transport (teeth loss, loss of particular bones that could be useful in criminal investigations, such as the hyoid bone...). The utility of this kind of "field mortuaries" in Kosovo was previously described by Beauthier et al. (2000).

As for the autopsy room management, all DVI teams deployed and working in that place should accept the agreed "Standard Operating Protocol" conditions (SOPs) and these conditions really are the rules of engagement.

The presence of a chief autopsy room manager, supervising the activities of the different teams and managing the arrival of new bodies, has proved to be of exceptional added value. At the same time, this person should have the power to enforce the SOPs and take any necessary actions if problems occur.

2. Identification criteria and techniques

2.1 General considerations

The proper identification of a decedent is not only important for humanitarian reasons for the next-of-kin but also for legal and administrative purposes. This identification issue

represents one of the most difficult medico-legal and anthropological tasks as it must withstand legal scrutiny.

All possible means must be applied to achieve a scientific identification, which is sometimes extremely difficult, particularly in mass disaster situations (Lunetta et al., 2003; Poisson et al., 2003; Tsokos et al., 2006) or in matters of genocide crimes. For some the mourning process starts as soon as the family members are aware of the suspected loss but the positive identification of the decedent also may be needed and helpful with so-called "closure."

Some families feel that the uncertainty is more difficult to cope with than the definitive identification.

From both legal and administrative points-of-view, non-identification creates additional problems.

2.2 Forensic anthropology

Regardless of the body's condition, the forensic and anthropological methods used during the different stages of the identification process must be rigorous and systematic (Djuric et al., 2007; Djuric, 2004).

Forensic anthropology is the application of the science of physical anthropology to the legal process. The identification of skeletal, badly decomposed, or otherwise unidentified human remains is important for both legal and humanitarian reasons. Forensic anthropologists apply standard scientific techniques developed in physical anthropology to identify human remains and also – if necessary – to assist in the detection of crime (Baccino, 2004; Beauthier, 2009; Cattaneo & Baccino, 2002; Cattaneo, 2007).

When discovering a skeleton, the physical anthropologist's aim is to prove its origin (by studying the rituals of burial, the ancestry, and the osseous characteristics which can provide interesting information on lifestyle, occupational activities, or hierarchical status).

The forensic anthropologist, who uses the same methods as his alter ego, works ultimately as an identifier and a medico-legal expert, looking for possible clues of criminal acts.

2.3 Identification process

Reconstructive identification is the first step needed to be able to achieve a comparative identification. During the reconstructive identification process all necessary information – physical characteristics, medical, odontological, DNA, fingerprints, etc. – is gathered from the unknown body so that an objective reconstructed profile of the unknown body can be established. This reconstructed PM profile can then be matched with missing persons' AM information in a comparative identification.

The Interpol DVI Standing Committee developed DVI Guidelines in the 1980's to promote the use of standardized AM and PM forms across personal and national preferences in all member countries.

(<http://www.interpol.int/public/DisasterVictim/guide/default.asp>).

These Interpol AM and PM forms are completed separately. Only in a later stage are the AM and PM information cross checked in order to lead to a final identification. These PM pink forms are completed by the multidisciplinary team during the different stages of the PM body examination as all useful elements for identification are systematically indexed on the PM Interpol form.

The AM data are collected from each presumed victim's family.

This information can be collected at their home or at a place where the family members are gathered, close to the disaster scene or at a distant location, according to the type of disaster and/ or the wishes of the families.

Further and/ or more specific information will then be collected from friends and acquaintances, the missing person's employer, doctor or dentist. It is also important to obtain pictures of the presumed victims and to collect their fingerprints. Hair samples, toothbrushes or other personal belongings of the missing person that can be useful to determine a DNA profile will be searched for and collected.

The family lineage will be established to determine from which relatives blood or saliva samples must be collected in case DNA analysis will be necessary for victim identification. AM fingerprints are collected at the homes of the presumed victims from objects likely only touched by them (e.g. a perfume bottle for women or an after shave bottle for men).

The AM forms (yellow) are completed by the team contacting the alleged victim's family and collecting (i) medical and surgical antecedents, (ii) morphological characteristics, (iii) professional antecedents and characteristics that result from these, (iv) dental information (De Valck, 2006), (v) description of clothing, jewelry, and other personal objects worn by the missing person, (vi) missing person's pictures.

All collected AM data, even partial, are transmitted to the Identification Section and transcribed into the computer data file. The computer team works with the "DVI International" software program, developed by PlassData™ and used by the Interpol DVI Community worldwide.

This software program allows research and automatic comparisons between AM and PM data bases in both directions: AM to PM or vice versa. (Andersen Torpet, 2005; Brenner, 2006; Clement et al., 2006). The by-the-computer-suggested correspondences between an unidentified body and a missing person facilitate a more specific manual control and comparison of the corresponding AM and PM data by a team of specialists.

This team informs the Chief of the Identification Team about a final decision on the identity of the unidentified human remains.

The rigid application and the respect for the Interpol International Conventions (e.g. the dental classification and the symbols used for a correct registration of the various dental treatments) enabled an optimal procedure leading to the positive identification of these innumerable victims (De Valck, 2006).

The actual Interpol forms currently also contain an important DNA document, indicating the methods and the probes to be used, in order to allow a uniform comparative application at an international level (Ladika, 2005).

Note that at the end of the first week, the Thai Tsunami Victim Identification committee (TTVI) was created in order to establish Standard Operation Protocols for data collection and identification procedures (Tsokos et al., 2006).

The Thai Tsunami Victim Identification Information Management Center (TTVI – IMC) under the direction of the Royal Thai Police, coordinated the collaboration between the international Disaster Victim Identification Teams and Thai authorities.

(http://www.interpol.int/Public/asiandisaster/background/TTVI_FAQ.asp)

Once all PM and AM data were entered into PlassData™, the system conducted a daily automatic search to identify possible matches. These were then manually verified by members of the reconciliation team to confirm the eventual identity of a victim. All information used in the comparison process was then compiled and presented to the

Reconciliation Board, composed of specialists from all areas of forensic and investigative expertise, for final confirmation.

Once identification was confirmed, a death certificate was issued and the body released ([http:// www.inet.co.th/ tsunami/ procedures.php](http://www.inet.co.th/tsunami/procedures.php)).

The authorities of the victim’s country were then contacted so that the victim’s family could be informed about the positive identification and that repatriation of the body could take place.

In concordance with the literature, we resume in Table 2, the different identification’s criteria (Beauthier, 2008; Beauthier et al., 2008; Beauthier & Lefèvre, 2008; Beauthier et al., 2009; Beauthier & Lefevre, 2007; Quatrehomme, 2003).

Qualities of Identification	Examples
Certitude	X-ray comparisons
	Dental comparisons
	Fingerprint comparisons
	DNA
Probable Identification	Identity documents
	Tattoos ²
	Compatible dental formula
Possible Identification	Scars ³
	Pathological antecedents
Identification excluded	Incompatible dental formula
	Pathological antecedents (e.g. bone fracture) incompatible

Table 2. Medicolegal Identification possibilities (Quatrehomme et al., 1998).

2.4 DNA techniques

Because of the rapid decomposition and subsequently muscular alterations, a sampling of the femoral shaft (recommended for DNA analysis) was carried out by the anthropologist. This happened in a separated area, using clean tools different from those used for autopsies. Another possibility for DNA sampling was the extraction of two sound teeth, preferably two premolars or canines, because of the presence of a lot of pulp material inside these teeth.

3. Discussion – guidelines

From an administrative point of view we believe though that it is imperative to adopt, from the beginning of an operation, a single and final numbering system for each unidentified body. This should be determined by the management in a Standard Operating Protocol (SOP). For the same reason, the teams must be deployed to the disaster site as soon as possible. Early body examinations, a fast and unique numbering system, and the possibility of in situ pictures will considerably improve the chances of a positive identification.

A chief DNA manager can operate away from the main autopsy room. This DNA manager would be responsible for the sampling of the DNA femoral shafts and making sure there is no permutation of the Interpol forms corresponding to the bodies.

² In certain cases, the identification can be certain.

³ With the same considerations than tattoos.

On a DNA level, it is useful to systematize the sampling of the dental and femoral diaphysis parts. In Thailand costal samples were taken from numerous bodies in the early days, but at a later stage instructions were given to start all over and instead collect the SOP approved femoral samples and/ or teeth.

Only performing an external body examination has limitations and we all were well aware of that. In this particular case and because of the body conditions the search for scars for example proved to be inadequate, but tattoos however were more easily detected and of great value.

The assistance of the local Thai auxiliary personnel in interpreting or translating some of the tattoo material was of great added value.

The benefits of a separate X-ray room (Ludes et al., 1994) where radiological examination of the body by X-ray amplification⁴ would allow to locate the presence of foreign bodies (e.g. osteosynthesis, prosthesis, tubar clips, vascular stents or pacemakers) are without any doubts and this idea should be taken into consideration at all times.

Radiology could be complementary - or even replace - the limited internal autopsy which provided very little helpful information as to validly evaluate anatomical characteristics under these difficult conditions (Hirsch & Shaler, 2002).

An important place in the PM information gathering was located at the final desk (Fig. 21) by (i) checking if all examinations were carried out; (ii) checking concordance of all



Fig. 21. Final desk.

⁴ Or CT-Scan.



Fig. 22. Bodies' conservation (with repertory) in containers – after all PM techniques.

numbered samples with the given body number ; (iii) assuring quality control of the dental X-rays (Goodman & Edelson, 2002; Kieser et al., 2006) and (iv) quality control of all documents.

Only after meeting all these quality criteria can the body be carried out of the technical autopsy rooms and stored in an appropriate refrigerated container, where its exact location is registered by the body handler (Fig. 22).

The efficiency of the adopted methodology is strictly depending on the kind and nature of the mass disaster. Each disaster is different and the approach adapted accordingly.

The final identification results depend mainly on the presence and quality of the AM information (physical evidence such as X-rays elements (Goodman & Edelson, 2002; Messmer, 1982; Rutty et al., 2007), fingerprints if possible⁵, dental records (De Valck, 2006; Kieser et al., 2006; Poisson et al., 2003) and of course DNA (Gill, 2006).

In 2006 Perrier mentioned – when referring to the Phuket identifications – the effectiveness of the following methods: 73% of identification by odontology, 24% by dactyloscopy and 3% by DNA analysis (Perrier et al., 2006). This shows the need to first focus on simple, inexpensive and quickly efficient methods, without diminishing of course the value of fingerprints and the excellence of the positive DNA identifications (Andersen Torpet, 2005; Biesecker et al., 2005; Brenner, 2006; Deng et al., 2005; Hinchliffe, 2007; Leclair et al., 2004; Leclair et al., 2007; Salo et al., 2007; Schuller-Gotzburg & Suchanek, 2007; Tack et al., 2007; Tsokos et al., 2006).

⁵ See: [http:// www.inet.co.th/ tsunami/ procedures.php](http://www.inet.co.th/tsunami/procedures.php).

Sribanditmongkol et al. reported similar conclusions⁶. The predominant role of forensic odontology was also underlined by Kirsch et al (2007). This highlights the need to first focus on simple, inexpensive and time-efficient methods, of course without minimizing the value of fingerprints and the excellence of DNA which are decisive in the identification process (Andersen Torpet, 2005; Biesecker et al., 2005; Brenner, 2006; Deng et al., 2005; Hinchliffe, 2007; Leclair et al., 2004; Leclair et al., 2007; Salo et al., 2007; Schuller-Gotzburg & Suchanek, 2007; Tack et al., 2007; Tsokos et al., 2006).

In December 2008, The Thai Tsunami Victim Identification and Repatriation Center mentioned that 388 bodies remain unidentified from a total of 3,696 examined bodies on the Wat Yan Yao Site 1a (Beauthier et al., 2009)⁷.

4. Conclusion

Adequate victim identification management goes through strict methodology and protocols. This requires adopting and applying standard operating protocols, in agreement with the Interpol DVI Standing Committee guidelines. Such requirements are even more amplified when faced to a mass disaster, such as the Tsunami of December 26, 2004, with numerous victims of different nationalities and ethnic origin.

Such a huge operation requires a multidisciplinary team like the Belgian DVI Team, which in addition to scientific experts, includes a significant number of police officers able to multitask and capable of efficiently assisting the team's scientific personnel.

The members of the civil protection, bringing in their technical knowledge and skills to improve the overall working conditions also proved to be of great value.

In addition, the Belgian DVI team is probably one of the only teams in the world to have a physician, a nurse, a psychologist and a stress team as regular team members.

The expertise in relation to disaster victim identification is enhanced when team members – working together in an interdisciplinary way, share mutual respect – are professionally trained and skilled, and have multi-functional capacities.

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⁶ See : http://www.who.int/hac/events/tsunamiconf/presentations/2_16_forensic_pongruk_doc.pdf, pp., www.paho.org/English/DD/PED/PungrukWHO_Lima.ppt,

⁷ See also : http://www.upi.com/Top_News/2008/12/24/Unidentified-dead-in-Thai-tsunami-at-388/UPI-85381230142146/.

⁸ <http://homepages.ulb.ac.be/~labo/>

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Submarine earthquakes, submarine slides and impacts may set large water volumes in motion characterized by very long wavelengths and a very high speed of lateral displacement, when reaching shallower water the wave breaks in over land - often with disastrous effects. This natural phenomenon is known as a tsunami event. By December 26, 2004, an event in the Indian Ocean, this word suddenly became known to the public. The effects were indeed disastrous and 227,898 people were killed. Tsunami events are a natural part of the Earth's geophysical system. There have been numerous events in the past and they will continue to be a threat to humanity; even more so today, when the coastal zone is occupied by so much more human activity and many more people. Therefore, tsunamis pose a very serious threat to humanity. The only way for us to face this threat is by increased knowledge so that we can meet future events by efficient warning systems and aid organizations. This book offers extensive and new information on tsunamis; their origin, history, effects, monitoring, hazards assessment and proposed handling with respect to precaution. Only through knowledge do we know how to behave in a wise manner. This book should be a well of tsunami knowledge for a long time, we hope.

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