Virtopsy & forensic imaging: legal parameters and impact

Abstract:

The Virtopsy®-project was launched at the Institute of Forensic Medicine in Bern, Switzerland, more than 15 years ago with the aim of replacing or supplementing traditional forensic autopsy by three dimensional photogrammetry-based optical body surface scanning (3D surface scan), postmortem computed tomography (pmCT), postmortem magnetic resonance imaging (pmMRI), CT-guided postmortem angiography (pm CT angio) and CT-guided postmortem biopsy (pm biopsy). Since that time pmCT scanning (and in a few forensic centers pmMRI or pm angio) has been incrementally introduced in many forensic death investigation facilities all over the world. Virtopsy/forensic imaging like pmCT or pmMRI is used to document cases of sudden or unexpected death of (unknown cause) or unnatural deaths and identification of bodies. CT, MRI and 3D surface scan have also found application in the clinical forensic medicine facilities of several forensic departments, for example to document and analyse cases of choking (attempted strangulation). Both Virtopsy and forensic imaging by pmCT (or pmMRI) may obviate the need for traditional forensic autopsy in determining a cause and/or a manner of death without dissection. Other advantages of Virtopsy and forensic imaging include 3D pictorial demonstrations of complex pathological processes for evidentiary/court purposes as well as a permanent digital record of the state of a body at the time presentation.

This paper will consider legal issues which arise relating to the current practice of Virtopsy and forensic imaging by pmCT (or pmMRI) in a comparative law study on the hand of the main examples Australia and Switzerland, with specific reference to statutory interpretation. The main focus is on the (possible) impact of Virtopsy and forensic imaging by pmCT (or pmMRI) in the (different) death investigation systems in both countries and includes criminal investigation, criminal procedure as well as coronial legislation. Moreover, the author aims at giving a short overview of relevant legislation not only regarding death investigation but also regarding the impact of clinical forensic imaging by CT, MRI or 3D surface scan on criminal proceedings as well as evidence law questions like e.g. admissibility of Virtopsy or pmCT/MRI images in (criminal) courts. In conclusion, it will examine whether this new technology is satisfactorily accommodated by current law or whether amendments might be necessary.

1. Background: The Swiss Virtopsy® approach:

One of the starting points of forensic imaging and thus of this article is the Swiss Virtopsy® project which was launched at the institute of forensic medicine of the University of Bern, Switzerland, more than 15 years ago. The term Virtopsy® was created from the terms “virtual” and “autopsy”: these words are derived from Latin and old Greek terms “virtus” and “opsomei”. The combination of the meaning of these terms results in “to see better or more efficient” (“virtus” = good, efficient; “opsomei” = I will see) [1-11]. Virtopsy® combines surveying technology, pathology, radiology, image processing, computer sciences, telematics, physics, and biomechanics. Virtopsy® is consisting of the following tools:

- 3D photogrammetry-based optical surface scanning (hereinafter called: 3D surface scan)
- Postmortem computed tomography (hereinafter called: pmCT)
- Postmortem magnetic resonance imaging (hereinafter called: pmMRI)
- Postmortem CT guided biopsy (hereinafter called: pm biopsy)
- Postmortem CT guided angiography (hereinafter called: pm CT angio) [1-11].

Data merging of the 3D surface scan and pmCT and pmMRI for 3D reconstruction is a “key” element of the project. Furthermore, the Virtobot, a forensic robot, with which the 3D surface scan as well as the pm biopsy are performed, completes the Swiss Virtopsy® [1-3, 11, 12]. It allows a full automatically CT guided postmortem tissue sampling. Other Virtopsy® approaches of the Swiss research team concern the use of Micro MRI and Micro CT for a kind of histological examination by

1 Bern Graduate School of Criminal Justice, University of Bern, Schanzeneckstrasse 1, 3001 Bern, Switzerland,
Email: david.zimmermann@krim.unibe.ch
non-invasive imaging, the impact of diffusion MRI in examination of bodies, the development of biomechanical models and MR spectroscopy to estimate the time of death [1-3].

The course of action of a full Virtopsy® -which has only been fully performed for scientific purposes and in a few specific cases in daily Bernese forensic practice- is the following one:

First, 3D photogrammetry followed by a 3D surface scanning with a GOM ATOS III 3D digitizer mounted on the Virtobot arm is performed. 3D surface digitizing is an optical measuring method based on the principle of triangulation, which is normally used for 3D documentation and measurements in prototyping and design technology, where a very high precision is required. This tool is used to document above all patterned injuries and objects of forensic interest, for example weapons or whole cars as well as whole crime scenes. Secondly the body is moved into a CT scanner (e.g. Siemens Somatom 6 [1] or a Siemens Somatom Definition Flash Dual Source CT²). PmCT scanning delivers good results for bones, fracture systems, pathologic gas collections such as air embolism or hyperbaric trauma as well as gross tissue injury [1-11].

The next step is a full body pm MRI scan (e.g. Phillips Achieva 3.0 Tesla³). PmMRI is used to exanimate soft tissue injuries, organ trauma and non-traumatic conditions [1, 2]. Moreover it is also well suited to the examination of surviving victims of choking in clinical forensic medicine to document inner neck findings to prove a danger for victim’s life [13, 14].

Further, a pm CT angio by a heart lung machine and contrast medium (e.g. mixture of PEG (polyethylene glycol) and a water-soluble contrast medium is performed [3]). With the application of a pm CT angio, it is also possible to display the vessel system. It supports the vascular cross section diagnostic and enables examination of structures are either not visible or visible only with major destruction of the corpse during traditional autopsy [1-3]. Last but not least a pm biopsy is performed with the Virtobot system. This type of needle placement by a radiologist using 3D tracking camera and CT volume data sets can be used for minimally invasive post mortem tissue and liquid sampling for histological and toxicological or other examinations [1-3].

Virtopsy® is above all used in forensic pathology to detect the cause and manner respectively circumstances of the death as well as to determine the identity of the deceased. Virtopsy® can supplement autopsy or serve as a triage to decide whether an autopsy should be done. Furthermore, the tools of Virtopsy® like MRI or CT are used in clinical forensic medicine as well, that means during medical examinations to injuries of living people (e.g. in cases of physical assaults respectively violent crimes against the person to document injuries of victims like inner neck findings in choking cases and bullets, drugs (“body-packing”) on suspects) [13-15]. A goal of the Swiss Virtopsy® project is to replace full invasive forensic autopsy by these minimally-invasive new technology in future [1-11]. As at this time around 80% of the forensic relevant causes of death (e.g. “fatal hemorrhage”) can be detected by using Virtopsy® -consisting of a 3D surface scan, pmCT, pmMRI, pm CT angio, pm biopsy tissue sampling for histological, toxicological, microbiological examinations- compared to the results of forensic autopsies according the studies of the Swiss research group [2].

There are some disadvantages of this imaging technology like limited tissue resolution by current scanning technology, no visualization of organ colors and depending on the used non/minimally-invasive procedures and the numbers of procedures the cost of Virtopsy® [2]. Average costs for a full forensic autopsy come to about AUD 2500.-, while the charges for a full Virtopsy® consisting of a 3D surface scan, pmCT, pmMRI, pm CT angio and pm biopsy at the Institute of Forensic Medicine in Bern are valued at around AUD 5000.- ⁴. However, in practice mostly only pmCT is performed, which is charged at the authorities for a much lower price (about AUD 400-500 per hour depending on the country and the complexity of the case)⁵. Additionally, the costs for the authorities that order a full Virtopsy® will decrease if the number of performed full Virtopsy®-examinations and technical progress would increase. Furthermore, Virtopsy®/forensic imaging reduces the autopsy rates and costs as well as it might decrease costs for legal trials and disputes because of the objections to autopsy by the relatives.

However, these disadvantages of Virtopsy® are faced with its many advantages, which include:

² Lars Ebert, Michael Thali, Institute of Forensic Medicine Zurich, Switzerland
³ Lars Ebert, Michael Thali, Institute of Forensic Medicine, Zurich, Switzerland
⁴ Information of the Institute of Forensic Medicine Bern, Switzerland
⁵ Chris O’Donnell, Victorian Institute of Forensic Medicine, Melbourne, Australia, Michael Thali, Institute of Forensic Medicine, Zurich, Switzerland
- 3D illustration and actual size documentation for an easier communication between e.g. lawyers and forensic experts. The 3D illustration and real scientific animation based on real data improve also the understandability of complex pathological findings respectively forensic evidence in court;
- digital stored data (3D images) on computers is accessible any time. That allows a digital re-examination of the body and a possible crime in e.g. cases of a retrial or de novo evidentiary hearings. Because the state of the body can be examined any time after liberation of the crime scene, burial or rot of the corpse even decades later, exhumations can often be unnecessary;
- digital archives of the Virtopsy® findings facilitates a second-opinion by another forensic expert or institute placed anywhere in the world (Teleforensic/-pathology);
- the whole process is observer-independent and results in an objective data archiving because of mechanical precision;
- no forensic evidence is touched or even destroyed. The non-destructive, minimally-invasive Virtopsy® allows a (better) examination of massively destroyed bodies (e.g. hit by train or burnt bodies);
- examination of difficult body areas for traditional forensic autopsy like e.g. pelvis or neck, a body can be scanned from “tip to toe”;
- no risk of infection (e.g. tuberculosis, toxic substances) and
- higher acceptance by the relatives, who do not tolerate and object to traditional forensic autopsy because of religious or cultural reasons (e.g. Muslims, Jews) [1-11].

The combination of CT guided pm angio with both image-guided specimen sampling for histology and toxicology or other examinations by pm fine-needle biopsy and whole-body pmMRI may serve as a viable alternative or at least as worthwhile supplement to traditional forensic autopsy while still guaranteeing the quality of the clinical and forensic assessments [1-3].

2. Current practice in Virtopsy/forensic imaging: an overview

The above mentioned Virtopsy® project of the forensic institutes in Bern and Zurich, Switzerland, and its advantages may be seen as a kind of starting point of forensic imaging worldwide. All over the world, other forensic research groups have been investigating the impact of forensic imaging on death investigation and forensic autopsy and the relating imaging tools, above all pmCT, pm CT angio and pmMRI. Further forensic (or medico-legal or medical examiner’s) institutes (or departments or offices) have introduced above all the most practical "Virtopsy-tool", a CT scanner, and a few, an MRI scanner in their facilities for pathological purposes. Others are using in-hospital CT (or MRI) scanners for death investigation (and for clinical forensic purposes too). The following "world overview" concentrates on forensic imaging (Virtopsy) in death investigation and above all on its different use either as an autopsy adjunct to or as a triage for autopsy (decisions).

a) Virtopsy/forensic imaging as an adjunct to autopsy:

- Switzerland:

The forensic institute in Bern, Switzerland, is the only institute worldwide that owns and uses a 3D surface scan, pmCT, pmMRI, pm CT angio and pm biopsy (equipment). Nevertheless, pmMRI, 3D surface scan, pm CT angio and pm biopsy serve above all for scientific purposes and are performed in daily death investigation under Article 253 of the Swiss Code of Criminal Procedure only in a few specific cases (to supplement autopsy). The daily practice of forensic imaging at the above mentioned institutes of forensic medicine in Bern and Zurich, Switzerland, is the following: In about one third of all reportable deaths (“extraordinary deaths”) at Bern a pmCT is performed as an adjunct to autopsy, that means after the responsible state prosecutor has come to an autopsy decision. The practice of using forensic imaging as an adjunct to autopsy after the autopsy decision by the state prosecutor- can be found also at the other Swiss forensic institutes, whereby the Institute of Forensic Medicine Zurich is using pmCT in each death case compared to Bern, but pmMRI also only in specific cases. While the collaborating forensic institutes in Lausanne and Geneva are using pmCT and are able to perform a pm CT angio in particular cases, the forensic institutes in St. Gallen and Basel (will) use pmCT6. Furthermore, forensic imaging has already served as evidence in homicide cases as well as in cases of attempted homicide, assault or endangering life (e.g. attempted strangulation) in Swiss criminal trials7.

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6 Michael Thali, Institute of Forensic Medicine, Zurich, Switzerland
7 Not published decrees by the district courts of the Cantons Bern and Aargau and Superior Court of the Canton Bern, SK-Nr. 2006/189/KOM, 05 09 2006
In other European countries a similar practice of Virtopsy/pm forensic imaging in a “judicial” death investigation system (prosecutor or police is responsible) can be noticed:

- Denmark:

All three Danish forensic institutes in Aarhus, Copenhagen and Odense are using pmCT as autopsy adjunct in all cases except the body does not fit in the scanner. Copenhagen is only one of three forensic institutes in Europe (besides Bern and Zurich) possessing an own MRI scanner for specific cases (and scientific purposes). After an external examination the police decide in collaboration with the forensic pathologists if an autopsy should be done. All cases of (suspected) homicides, unknown matter of death and illegal drug related cases and most sudden and unexpected deaths in prison and hospital undergo an autopsy and pmCT (or pmMRI) as supplement.

- Sweden:

In Linköping, Sweden, the forensic institute uses a pmCT placed in its research center as an adjunct to autopsy. The police department decides about the examination method, which is in almost all cases an autopsy which may include a pmCT. The other five Swedish forensic institutes in Stockholm, Uppsala, Stockholm, Goteborg, Umeå and Lund follow the same practice, but are using in-hospital CT.

- France, Australia (without Victoria), Singapore, Malaysia, Saudi Arabia, Israel, USA, Japan (legal-medicine departments):

Forensic facilities in other European countries use in-hospital CT (or MRI) as an adjunct to autopsy, like e.g. the French forensic institutes in Toulouse, Marseille, Grenoble, Rouen, Rennes, Lyon, i.a.

Outside of Europe, two Australian forensic departments in Newcastle/NSW and Brisbane/QLD: one forensic institute in Singapore and in Israel as well as the Israeli ministry of health (which owns an additional MRI scanner); one forensic institute in Kuala Lumpur, Malaysia; a forensic facility in Riad, Saudi Arabia; three US American institutions (Office of the Chief Medical Examiner in Baltimore/Maryland, Office of the Medical Investigator in Albuquerque/New Mexico, which is installing also an MRI scanner, and the US Air Force Base in Dover/Delaware only for military fatalities) and 19 forensic institutes at Japanese Universities use their own CT scanner to perform a pmCT as an adjunct to forensic autopsy in suspicious cases. Two of these 19 Japanese legal medicine departments, Fukui and Tohoku, possess an MRI scanner for only postmortem purposes as well.

b) Virtopsy/pm forensic imaging as a triage for autopsy:

- Victoria, Australia:

Following pmCT practice has been anchored at the Victorian Institute of Forensic Medicine (VIFM), Melbourne, Australia, as one of the leading institutes in forensic imaging: In 2005 a CT scanner was installed in VIFM’s mortuary and all deceased persons, which are provided by the coroner (except bodies, which does not fit in the scanner, e.g. because of their weight, 150 kg +) have been undergone a pmCT [16, 17]. PmCT is used to provide information for the pathologist for his or her forensic autopsy, e.g. regarding the cause of death, as well as for identification purposes (e.g. “Black Saturday” Victorian bushfires, 2009) [17, 18]. The pathologists have been trained in reading the pmCT images. Moreover, a radiologist is working for the VIFM to overview (specifically) the cases and serving as a consultant and “coach” for the pathologists and registrars. Forensic technicians in the mortuary are trained in radiography and performing also pm CT angio. Soon, the VIFM will replace the current CT scanner, which examined more than 20’000 cases, by a new Siemens Somatom Definition Flash Dual Source CT scanner. The upgrade of the CT scanner shall allow a faster scanning of the bodies, examinations of larger or heavier bodies and improve diagnosis in general [16]. Moreover, the VIFM is one of the few forensic institutes worldwide (besides Bern, Zurich, Lausanne/Geneva), that is using pm CT angio in daily death investigations. Only a few cases (~1-2%) undergo a pm CT angio, either to

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8 Hans Petter Hougen, Department of Forensic Medicine, Copenhagen, Denmark
9 Steffen Ross, Johan Berge, Institute of Forensic Medicine, Linköping, Sweden
10 Fabrice Dedouit, Service de Médecine Légale, Toulouse, France
11 Gil Brogdon, University of South Alabama, USA; Chris O’Donnell and Noel Woodford, Victorian Institute of Forensic Medicine, Melbourne, Australia; Seji Shiotani (Tsukuba Medical Center) and Morio Iino (Osaka University), Japan; Jehuda Hiss, Abu Kabir Institute of Forensic Medicine, Israel; Steffen Ross, Institute of Forensic Medicine Linköping, Sweden; Gary Hatch, Garyfalia Ampanozi, Saiful Nizam Abdul Rashid, Institute of Forensic Medicine Zurich, Switzerland
12 Chris O’Donnell, Victorian Institute of Forensic Medicine, Melbourne, Australia
supplement the forensic autopsy or in particular cases, for which an objection by the relatives of the deceased exists, additional information can be provided by using pmCT angio with the coroner’s consent to avoid forensic autopsy. The Coroners Act 2008 in Victoria and its preliminary examinations have had a significant effect on the daily forensic practice at the VIFM: the number of full forensic autopsies has fallen, on the other hand the number of inspections including toxicology investigations, external examination and pmCT during the preliminary examinations has significantly increased [13] [17]. PmCT at the VIFM is used during the preliminary examinations and before the autopsy decision by the coroner. PmCT (and with consent by the coroner pm CT angio) is an important triage tool to facilitate the coroner’s decision whether an autopsy is necessary or not.

-Germany:

Most German forensic institutes use in-hospital CT (or rarely MRI) equipment for postmortem purposes, however the forensic institutes in Hamburg, Heidelberg, Ulm, Berlin own a CT scanner for pathological purposes. For German criminal trials an autopsy has to be performed and pmCT (or rarely pmMRI) may serve as an autopsy adjunct in such criminal cases. However, under § 87 (1) of the German Code of Criminal Procedure it is possible to perform a pmCT (or pmMRI) scan during the (external) inspection of the body (“Leichenschau”) as a triage for autopsy [14]. Therefore, pmCT has been used for instance in Bremen to avoid a forensic autopsy in SIDS cases. At the forensic institute in Hamburg, pmCT is even routinely used as a triage during the inspection, to decide whether an autopsy should be done or not. The external examination (“Leichenschau”) has to be performed in every reportable death, while a pmCT during the inspection may be performed [15].

In the following countries in-hospital CT (or MRI) serve as a triage to an autopsy, this means to decide whether an autopsy should be done or not in particular cases:

-Japan:

In Japan the police and in the five biggest cities like Tokyo, Osaka i.a., medical examiner’s offices use existing hospital CT (or MRI) data of the body (in cases where the person died in hospital) or ask a hospital to perform a CT (or MRI) scan on the body in non-suspicious or non-criminal cases during a so-called administrative inspection. None of the 5 medical examiner’s offices possess an own CT or MRI scanner today. In those cases, usually no (administrative) autopsy is performed and it is replaced by pmCT (or pmMRI) and external examination. However, an additional (administrative) autopsy by clinical doctors may take place, if either the relatives consent to or require it at the police or prosecutor or in the cases of a medical examiner’s investigation, he or she can perform an autopsy (without consent), if he or she thinks it is necessary. If a criminal offence is suspected or detected during such an administrative investigation by the police or medical examiner, the body is provided at a legal-medicine department to perform a (judicial) autopsy by a pathologist (including a pmCT or pmMRI). In 2007/2008, 2 of 1’800 non-suspicious cases in total were identified as criminal offences (homicides) because of pmCT/MRI at hospitals [16].

-United Kingdom:

In the UK, (forensic) institutes in Leicester, Manchester, Oxford and (soon) London use National Health Service hospitals’ CT or MRI under Sect 14 (2) of the Coroner’s and Justice Act 2009 [17]. In Manchester three private pmMRI services at hospitals scan reported death cases, which are unlikely to lead to attempt to convict anyone of a crime by pmMRI, for six coroners. These non-suspicious deaths are reported to the coroner above all because the general practitioner or hospital doctor could not issue a death certificate or a medical procedure which needs to be reported to the coroner, like e.g. a surgery, has recently carried out on the deceased person. These examinations can spare (including the clinical history) an autopsy, if no criminal offence should be detected during pmMRI (in around 13% of the cases) [18]. In Oxford, pmCT (or pmMRI) is used to avoid traditional autopsies in

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13 e.g. autopsy rates have decreased since the installation of a CT scanner for about 30% (2004-2005: 2370 autopsies out of 3462 cases; 2009-2010: 1977 autopsies out of 4550 cases. Inspections have increased: inspection incl. CT <- autopsy:2008/2009: 2696 full autopsies>< 657 inspections; 2009/2010: 1977 full autopsies>< 1661 inspections [18])
14 § 87 (1) of the German Code of Criminal Procedure
15 Hermann Vogel, Institute of Forensic Medicine, Hamburg, Germany
16 Seji Shiotani (Tsukuba Medical Center) and Morio Iino (Osaka University), Japan
17 Sect 14 (2) of the Coroner’s and Justice Act 2009 UK
high risk cases, such as HIV. However, in reported cases of suspicious deaths or (suspected) homicides pmCT (or pmMRI) is commonly used as an adjunct to autopsy in the UK\textsuperscript{18}.

\textit{-Italy:}

In Italy, forensic institutes in Foggia, Milan, Padua, Bari and Messina have the possibility to perform pmCT or pmMRI at hospitals as a routine. In general, pathologists in Italy can be authorised by the prosecutor to perform a pmCT or pmMRI as an adjunct to an autopsy. However, in natural disasters cases, like e.g. earthquakes, with more than 10 victims, pmCT or pmMRI has already replaced traditional forensic autopsy\textsuperscript{19}.

\section*{3. Legal side of Virtopsy/forensic imaging:}

\subsection*{a) Introduction:}

A look on Coroner’s Acts, Codes of Criminal Procedure, Crimes Acts, Health Acts of the legislations of Australia, Austria, Germany, Principality of Liechtenstein, Switzerland and USA on federal and on state level as well as a questionnaire of forensic radiologists in other countries like UK, France, Italy, Sweden, Denmark, Japan, Israel i.a. show that at least in the German and English speaking world no code, no act, no regulation –except the Coroners Act 2008 VIC and partially the Coroners Act 2009 NSW (see below)- mentions Virtopsy or forensic imaging such as pmCT, pmMRI, pm CT angio etc. explicitly. In every legislation, relevant sections in codes regarding forensic autopsy or postmortem (examination) can be found. Some of them uses further general terms like “further or additional investigation”\textsuperscript{20}, “other study”\textsuperscript{21}, “least invasive procedures”\textsuperscript{22}, “partial postmortem”\textsuperscript{23}, “other tests”\textsuperscript{24} etc. However, not everywhere regulations about the inspection of the body (“external examination”\textsuperscript{25}, “legal inspection”\textsuperscript{26}, “Leichenschau”\textsuperscript{27}, “Leichenbeschau”\textsuperscript{28}, “preliminary examination”\textsuperscript{29}) have been become law. No particular court decree is discussing the acceptance of Virtopsy or forensic imaging as evidence instead of traditional forensic autopsy or in general the acceptance of Virtopsy or forensic imaging as evidence in court; although roentgenograms (X-rays) as evidence have been found admissible and accepted by courts in England, Canada and the USA since 1896 [3]. Moreover, Virtopsy / forensic imaging, above all pmCT, found its way into court rooms as evidence in criminal trials as well as in coronial inquests, mostly with additional autopsy results, but rarely without them, for instance in Australia, Switzerland or Japan\textsuperscript{30}.

A deep literature review presents very rare publications in journals or books about the legal issues, which can arise around Virtopsy/forensic imaging. In Switzerland, Brigitte Tag in the journal “Forensik”\textsuperscript{31}, Ulrich Zollinger in the Basel Commentary to the Code of Criminal Procedure [19], Thomas Hansjakob in the Commentary about the Code of Criminal Procedure by Donatsch/Hansjakob/Lieber [20] and the Romandy Commentary to the Code of Criminal Procedure by Kuhn/Jeanneret [21] mention Virtopsy, forensic imaging or pmCT/pmMRI in legal literature as further examination procedures besides the traditional forensic autopsy and Article 253 Section 3 of the Swiss

\textsuperscript{18} Emyr Benbow (Manchester Royal Infirmary) and Mark Viner (Cranfield University), UK
\textsuperscript{19} Giuseppe Guglielmi, University of Foggia, Italy
\textsuperscript{20} Article 253 Section 3 Swiss Code of Criminal Procedure; Hawaii Statutes, § 841-14
\textsuperscript{21} Mississippi Code, Title 41: Public Health, Chapter 61, State Medical Examiner, Section 65: Autopsy, Reports; immunity from liability review of determination
\textsuperscript{22} Section 88 (2) Coroners Act 2009 NSW
\textsuperscript{23} Section 19 (3) of the Coroners Act 2003 QLD; Section 88 (3) Coroners Act 2009 NSW
\textsuperscript{24} Arizona Revised Statutes, Title 11 - counties, § 11-597
\textsuperscript{25} e.g. Australia: Section 19 (3) of the Coroners Act 2003 QLD; Section 88 (3) Coroners Act 2009 NSW; USA: Alabama Code, Title 15, Chapter 4, Section 15-4-2; Arizona Revised Statutes, Title 11 - counties, § 11-597
\textsuperscript{26} Article 253 Section 1 Swiss Code of Criminal Procedure
\textsuperscript{27} § 87 f German Code of Criminal Procedure
\textsuperscript{28} § 125 f Austrian Code of Criminal Procedure
\textsuperscript{29} Sections 3, 23, Coroners Act 2008 VIC
\textsuperscript{30} e.g. R v Ferguson [2007] NSWSC 949, Supreme Court New South Wales, 27 August2007; Krantz v Hand [199’ NSWSC 432, Supreme Court New South Wales, 23 April 1999; Coronial finding into death with inquest, Coroners Court Victoria, 2715/09, 8 December 2010; Coronial finding into death with inquest, Coroners Court Victoria, 3109/10, 6 June 2011, among many others; unpublished court decrees of the district courts in the cantons Bern and Aargau
\textsuperscript{31} Brigitte Tag, Rechtliche Aspekte der Forensik (legal aspects of forensic) in Informationsschrift KSA, Forensik, Heft 1/2010, S. 4-7 (in document for information, KSD, Forensic, Journal 1/2010, p. 4-7)
In Austria, Peter J Schick as first known author is discussing legal aspects like expert evidence with Virtopsy images and tries to interpret § 128 of the Austrian Code of Criminal Procedure about forensic autopsy [11]. In the book “The Virtopsy approach” by Michael J. Thali et al., Graham P. Segal debates legal, cultural and religious aspects of Virtopsy, above all its advantages in cases of objection by the next of kin to forensic autopsy in Jewish or Muslim communities, and analyses relevant Australian case law (e.g. Krantz vs Hand, Supreme Court NSW 23 April 1999, see below) in his article “Virtopsy and the law” [2]. Furthermore, Gil Brogdon in “Forensic Radiology, 2nd edition” discuss evidence law issues under the US Federal Rules of Evidence and the “Daubert Standard” regarding forensic imaging [3]. David Ranson investigates the Victorian Coroners Act 2008 and its preliminary examinations including pm forensic imaging like pmCT or future pm fine needle biopsies from a medical investigator’s perspective [22].

The results of a questionnaire by the author in collaboration with the Institute of Forensic Medicine Bern, Switzerland, at the prosecuting authorities (investigative judges in September 2010, replaced by the state prosecutors since 1 January 2011) of the Swiss Cantons Bern and Aargau showed that Virtopsy / forensic imaging are not much known and ordered by the prosecuting authorities so far (above all in the Canton Aargau compared to Bern). However, the use of pmCT and 3D surface scan in death investigations (and in clinical forensic medicine MRI scans of chocking victims [13, 14]) are already yet anchored in the prosecution of both. Furthermore, the prosecuting authorities recognise many of the above mentioned advantages, and an overvalue compared to only traditional examination procedures (and reports), particularly forensic autopsy (reports). The future of Virtopsy / forensic imaging was assessed, also in a legal point of view to its legal bases in the Articles 241, 249-252 (for clinical forensic imaging) and 253 (for Virtopsy/pm forensic imaging) of the Swiss Code of Criminal Procedure, in a positive way. The investigative judges have not seen any obstacles to include Virtopsy/forensic imaging as additional examination and partially or in specific cases as alternatives procedures to traditional examinations, like autopsy, to get evidence in prosecution and for (possible) criminal trials [23].

A recently published study by the forensic institute in Leicester/UK examines 8 different cases (2 fire deaths, 2 traffic deaths (pedestrian road traffic collusion, railway death), 2 stabbing cases (stab wounds, blunt and sharp trauma death), 1 ligature to neck death and 1 shotgun homicide) by a pm full-body CT scan and on the other hand by a full pm forensic autopsy (both including results of an external examination and scene details as well as toxicology results, that could be retrieved without dissection, where available) [24]. However, the histology results were not included in the non-invasive pmCT report, because histology was considered as more invasive examination and therefore only included in the autopsy report. Another consultant pathologist, who has not undertaken the forensic autopsy, formulated both reports with his routine conclusions including establishing a cause of death, where possible. On one hand, the 2 different reports (pmCT and autopsy report including histology) were compared. This comparison showed that 7 of the 8 causes of death “could be considered as unaltered with pmCT and without forensic autopsy (and histology)” [24].

On the other hand, it was investigated if the non-invasive pmCT report can meet the needs of the end users, i.e. police, prosecutor, coroner, criminal judge, barrister or solicitor [24]. For that purpose, only the pmCT report was provided to 5 judicial persons (criminal judge, barrister and solicitor, medical coroner, senior police officer), who answered a questionnaire (including free text answer possibilities) [24]. The results show that there are no significant concerns to the acceptance and completeness of the pmCT reports in criminal trials regarding straightforward trauma deaths such as the tow investigated accident cases arising of transportation [24]. The pmCT report in the case of ligature to neck death was also (almost) accepted by all participants. However 1 (barrister in the shotgun homicide) and 2 (medical coroner and police officer respectively, barrister) in the 2 fire cases rejected the completeness as evidence of the pmCT report. Even 3, respectively 4 legal participants refused their acceptance to the completeness of the pmCT reports in the two stabbing/sharp trauma cases [24]. The authors conclude that pmCT “cannot provide all of the information that is expected by the criminal justice system in complex forensic cases” [24]. In general, the writer raises the question whether a more comprehensive minimally-invasive examination report including tissue sampling by image guided fine needle pm biopsies to deliver histology results, pm CT angio (like used in the practice of several leading forensic institutes) to display the vessel system and pmMRI in addition to the CT scan to document soft tissue injuries could establish a different response from the judicial participants. They may have found such minimally-invasive results as acceptable, even for criminal trials. Particular

33 Victorian Institute of Forensic Medicine, Melbourne, Australia; Institute of Forensic Medicine, University of Bern, Switzerland i.a.
examples are the fire deaths, where it was not clear if the deceased died before the fire or because of the fire. A more comprehensive minimally-invasive Virtopsy-report might establish a satisfying result and acceptable evidence, even for criminal trials, by histology results using fine needle biopsies to sample tissue. Furthermore, it has to be stressed that the participant criminal judge as the “gatekeeper” for evidence in criminal trials did only not accept the non-invasive pmCT based reports of the 2 stabbing cases (stab wounds, blunt and sharp trauma death) and accepted the pmCT reports as complete evidence in the six other cases including the shotgun homicide [24].

That overview about legal literature or studies concerning Virtopsy/forensic imaging highlights that there are many legal issues, which may arise and have to be answered:

The protection of legal personality as well as the right to personal freedom and the end of these personality rights (e.g. so-called postmortem protection of legal personality in German jurisdiction (postmortaler Persönlichkeitschutztheorie) versus protection of the memory in Swiss jurisdiction (Andenkensschutztheorie)); questions of informed consent in clinical forensic imaging; data privacy issues regarding the storage of Virtopsy/forensic imaging data and evidence law questions, like particularly the acceptance of Virtopsy/pm forensic imaging results without supplementing autopsy results in the (criminal) court room, and as main issue to find and qualify legal bases in statutes or codes or in case law to provide generally the opportunity to order and perform Virtopsy/forensic imaging in criminal prosecution as well as in coronial or medical examiner’s investigations.

In the following chapters the writer gives an overview about the different death investigation systems in Australia, mainly on the hand of the example Victoria, and Switzerland, approaches legal bases for Virtopsy and postmortem forensic imaging in Australia and Switzerland. Moreover, a short excursus in possible legal bases for clinical forensic imaging and in evidence law relating to Virtopsy/forensic imaging shall inspire the reader for the necessary legal approach of that progressive method in forensic medicine.

b) Different death investigation: examples Australia and Switzerland:

Before any legal bases for Virtopsy/forensic imaging can be defined, it is necessary to get an impression of current death investigation systems. Different jurisdictions provide different death investigation systems. There can be systems which require consent of the relatives or other qualified parties to perform an autopsy (e.g. clinical autopsies, administrative autopsies etc.). Other death investigation systems do not need consent to perform an examination, including an autopsy. The coroner, the medical examiner or judicial authorities such as police or prosecutor (or district attorney) can order an examination including an autopsy without consent (but mostly a right to object is provided). Such compulsory death investigation systems can be found in most (developed) countries (i.a. in Australia, Japan, USA, and Europe). For instance, in the USA a “mix” of coronial and medical examiner's system exists. In Australia a coronal system is anchored, while in Switzerland a judicial death investigation by the state prosecutor has been established. The medical examiner systems in the USA and so-called judicial death investigation systems in most European countries including Switzerland focus whether a criminal behavior caused a death. Coroner's death investigation in Australia takes a broader and more public health related perspective. The circumstances of a death are investigated in a more intense way, also to avoid such deaths in the future, e.g. to avoid deaths because of negligent, defective or poorly coordinated health and safety practices, and to improve communication with and service to families of the deceased [26-29]. Therefore, Australian, at least Victorian, death investigation focuses mainly on the cause of death, while Swiss death investigation is focused on the manner of death. As consequence, in Switzerland—compared to Australia—no coronal system has been established, no coroners, no coroners courts, no coroner's inquests or hearings exist. The state prosecutor is responsible for the death investigation, since the new Swiss Code of Criminal Procedure entered into force on 1st January 2011 (before 2011 each of the 26 Swiss cantons had their own Code of Criminal Procedures and in several cantons such as Bern, the investigative judges were responsible for death investigation) [19-21, 30, 31]. This distinction of the death investigation’s focus is not irrelevant for the discussion of the legal side of Virtopsy/pm forensic imaging. Besides that main death investigation by the coroner or by the state prosecutor, in both countries the relevant public health departments or chief health officer of the states, territories or cantons are empowered under the relevant acts to require an autopsy without the consent of the

34 Statewide or county medical examiners: AK, AZ, CT, DE, DC, ME, MD, MA, MI, NH, NM, NC, OK, OR, RI, TN, TX, UT, VT, VA, WV; district medical examiner: FL; District or county Coroners: CO, ID, IN, KS, LA, NE, NV, ND, SC, SD, WY; mix of medical examiners and coroners: AL, AR, CA, GA, HI, IL, IA, KY, MN, MT, MS, MO, NJ, NY (NY city: medical examiner), OH, PA, WA, WI [25]
relatives, if an infectious disease could implicate a risk for public health\textsuperscript{35}. However, the present article focuses on the death investigation by the coroner or state prosecutor.

Both, Swiss criminal procedure and Australian coronial investigation and inquest are inquisitorial, that means the Australian coroner and the Swiss criminal judge actively investigate or are involved in the investigation of the case. In Switzerland, death investigation takes place during the criminal preliminary proceeding lead by the state prosecutor and ensures evidence for a possible following criminal trial [19-21, 30, 31]. In Australia, criminal trials do not take place at the same time like an inquest. Mostly, a coronial inquest follows a criminal trial, rather rare is the vice versa procedure. However, homicide prosecutions and following criminal trial rely often on autopsy reports and the only way that an autopsy can be performed is on the instructions of a coroner [26]. Therefore, the coroner also ensures evidence for criminal trial and not only for his coronial investigation. On the other hand, a coroner must not include in a finding or comment any statement that a person is or may be guilty of an offence, except the notice to the Director of Public Prosecutions (DPP) (or also in NT Commissioner of Police or in TAS Attorney General i.a.), if a(n) (indictable) offence is detected (e.g. Sect 62 Coroners Act 2008 Vic)[26-29]. In summary, Swiss death investigation is a part of the criminal procedure, while Australian death investigation is in the hands of the coroner. However, forensic examination, e.g. autopsy or Virtopsy reports which are established by forensic pathologists or other forensic experts, serve not only as expert evidence (including expert testimony) in Swiss criminal trials and Australian coronial inquests, but also in civil trials or public law trials of both countries as well as in Australian criminal trials (under the relevant standards of proof).

The "core" death investigation of both countries can be described as followed:

First, in both countries about 10% of all deaths are reported to the coroner in Australia respectively, the state prosecutor in Switzerland (and in fact mostly to the police or coroner’s clerk), the other ~ 90% of the death cases are handled by an administrative process, i.e. the medical practitioners and registrars of birth, death and marriages [19, 26, 32]. Above all medical practitioners, but also police, responsible persons in custody or care (or e.g. in Victoria also any person who believes that the death has not been reported) are under a duty to inform the coroner or the state prosecutor [19-21, 26-31]. Reportable deaths in Australia have to be connected in some way with the relevant state or territory and have to be, usually, unexpected, unnatural or violent; or resulted from accident or injury; or occur during/following medical procedures, or in custody or care; or the identity of the deceased is unknown or no death certificate has been given\textsuperscript{36}. However, there are few differences (in wording) between the 6 states and 2 territories. For instance, in Victoria, deaths occurred during or following medical procedures have to be reported if a registered medical practitioner would not, immediately before the procedure was undertaken, have reasonably expected the death to occur\textsuperscript{37}. Furthermore, only the Coroners Act 2008 Victoria know the construction of "reviewable deaths": a death of a child as the second or subsequent child of the deceased child’s parent and his or her death does not occur in a hospital where the child was born and always been an in-patient and death is not reportable is reviewable, i.e. the coroner has to investigate the death\textsuperscript{38}. In other states and territories other reportable deaths (or at least another wording) can be found: e.g. in NSW and ACT, a person, who had not been attended by a medical practitioner during a period of 6 respectively, 3 months immediately before the person’s death has to be reported\textsuperscript{39}. In TAS a death occurred during (an attempt to) escape from a prison, detention centre, police custody i.a. and a death of a child under 1 year, that was unexpected, have to be reported\textsuperscript{40}. In SA also "unusual deaths", death occurs on an aircraft or on a vessel during a flight or voyage (as well as in NT) have to reported, while in QLD death in “suspicious circumstances” and in the course or as a result of police operations are reportable i.a.\textsuperscript{41}

In Switzerland, so-called “extraordinary deaths” have to be reported by medical health practitioner; usually the physician called in relation to the death to the state prosecutor (or the police) according to Article 253 Section 4 SCCP and the relevant Health Acts of the Cantons (e.g. Bern, Article 28 Section 2) [19-21. 30-32]. Extraordinary deaths can be defined as deaths with no known natural cause or no

\textsuperscript{35} E.g. Sect 156 Public Health and Wellbeing Act Victoria; Sect 24 Health Act of the Canton Bern i.a.
\textsuperscript{36} Compare: Sect 4 Coroners Act 2008 VIC; Sect 3 Coroners Act 1995 ACT; Sect 6 Coroners Act 2009 NSW; Sect 12 Coroners Act NT; Sect 8 Coroners Act 2003 QLD; Sect 3 Coroners Acts 2003 SA, 1995 TAS and 1996 WA
\textsuperscript{37} Sect 4 Coroners Act 2008 VIC
\textsuperscript{38} Sect 5 Coroners Act 2008 VIC
\textsuperscript{39} Sect 3 Coroners Act 1995 ACT; Sect 6 Coroners Act 2009 NSW
\textsuperscript{40} Sect 3 Coroners Act 1995 TAS
\textsuperscript{41} Sect 12 Coroners Act NT; Sect 8 Coroners Act 2003 QLD; Sect 3 Coroners Acts 2003 SA
known precedent disease or occurred violent or violence is suspected (i.e. homicide, suicide, accident, medical malpractice) or unclear deaths, i.e. sudden and unexpected [19, 20, 32, 33].

Such a reported “extraordinary death” or if the identity of the deceased is unknown has to be investigated by the state prosecutor, who orders an experienced physician to perform a so-called legal inspection to clear the manner of death or the identity of the deceased (Article 253 Sect 1 SCCP) [19-21, 30, 31]. The legal inspection includes an external examination of the body including body cavities, taking samples from the body surface or cavities or blood or urine for further examination (no “overnight toxicology” is performed in Switzerland till end of 2011[42]), collect medical history information etc. however no Viertopsy/forensic imaging including pmCT takes place at the stage of legal inspection in Swiss forensic practice [19-21, 32].

In Australia, the practice and the Coroners Acts of the different states & territories show a very various picture:

Victoria is the only Australian state or territory, for which the Coroners Act 2008 implies “preliminary examinations” (Sect 3, 24 Coroners Act 2008 VIC). The coroner provides the reported (or reviewable) body to the Victorian Institute of Forensic Medicine (or in rural areas in Victoria to a pathologist at a hospital) for a preliminary examination. No order or consent by the coroner is necessary [17, 18, 22, 27, 28]. A preliminary examination involves an external examination of the body, collection of information and reviewing the circumstances of death including police reports, and health information such as medical records relating to the deceased and taking photographs and use pm forensic imaging of the body involving a CT scan and x-rays. The taking and testing of samples of bodily fluid such as blood and urine, the taking of samples from the surface of the body and identification procedures as well as rapid toxicological analysis of blood samples can complete the preliminary examinations [17, 18, 22, 27, 28]. After the preliminary examinations have been performed, a meeting between the duty pathologist and the duty coroner is held, during which all of the cases which have been reviewed in the preliminary examinations are discussed. Above all, because of the pmCT scan and rapid “overnight toxicology” of blood samples the pathologist is able to provide the coroner with a wide range and depth of information at an early stage of the investigation [17, 18, 22, 27, 28]. Because the coroner has to clear the circumstances of the death, the identity of the deceased and the cause of death, the most important medical information by the pathologist is to establish a reasonable cause of death during the preliminary examinations (if possible). However, the decision whether a forensic autopsy should be performed or an inspection (and report) is sufficient rests by the coroner, taking into account all circumstances, e.g. also the concerns of the family, i.e. objections to autopsy because of religious or cultural reasons, legal aspects and public health interests like death prevention the coroner has to decide if a forensic autopsy should be done or not. In specific cases, where a pm CT angio could help to avoid a forensic autopsy, the coroner may consent to perform a pm CT angio, before deciding about autopsy. Less than 50% of reported deaths undergo an autopsy since the introduction of the preliminary examinations in 2009 [17, 18]. However, the relatives cannot object to the preliminary examinations in VIC (compared to the possible objection in Article 393 SCCP to the legalinspection in Switzerland).

Both terms, “legal inspection” and “preliminary examinations” are unique worldwide (at least in English and German speaking countries). Not every legislation contains the duty to perform an explicit “2 step procedure”, i.e. first an inspection or external examination which can include pm forensic imaging before the autopsy decision as second step. Besides Victoria and Switzerland such a “2 step procedure” can be found, i.a. in Germany and Austria[43] and in several states in North America, such as Alabama[44]. In other legislations ‘only’ autopsy (or postmortem examination) are regulated[45] or besides the autopsy other terms like necessary examinations, investigations, studies, (laboratory) tests etc. (often for identification purposes) are used[46]. Autopsy as well as further necessary

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[42] Michael Thali, Director Institute of Forensic Medicine Zurich, Switzerland
[43] § 87, 89 German Code of Criminal Procedure; § 125, 128 Austrian Code of Criminal Procedure
[44] Sect 15-4-2, Code of Alabama, Title 15:Criminal Procedure
[45] E.g. Sect 4 of the Massachusetts Statutes, Part I, Title VI, Chapter 38 Medical examiners and inquests; Sect 27521 of the California Code i.a.
[46] E.g. Sect 406.11 of the Florida Statutes 2011, Title XXIX, Chapter 406 Medical examiners, disposition of dead bodies; Article 49.10 (k) of the Texas’ Code, Title 1Criminal Procedure, Chapter 49. Inquests upon dead bodies ; Sect 46-4-113 of the Montana Code annotated 2009; § 11:597 A of the Arizona Revised Statutes, Title 11 – counties, Sect 647 New York Code etc.
examinations, investigations, tests, studies etc. include usually an inspection/external examination of
the body. However, these codes or statutes do not explicitly provide such a “2 step procedure”.

Only the Victorian Coroners Act includes “preliminary examinations” in Australia. No other Coroners
Act in Australia except VIC uses the term ‘inspection’ or ‘preliminary examination’, but a few “external
examination” [35]: The new Coroners Act 2009 in NSW in its Section 88 mentions the terms
“postmortem examination or other examination or test”, “least invasive procedure”, which can include
but is not limited to an “external examination” or a “radiological examination” i.a.47. Therefore a “2 step
procedure” is distinguishable, i.e. the pathologist could perform e.g. an external and radiological
examination before the autopsy decision. Under Section 19 of the Coroners Act 2003 QLD the
autopsy may consist of an “external examination, or an “external and partial internal examination”, or
an “external and full internal examination of the body”50. The Coroners Acts of the other states and
territories do not include explicitly the terms “external examination” or “inspection” or “preliminary
examination”. The Coroners Act 2003 SA provides in Section 22 a “postmortem examination of the
body” and “any other examinations or tests consequent on the postmortem examination”49. The
Coroners Acts of the ACT, NT (Sect 20), TAS (Sect 36), WA (Sect 34) only mention “postmortem
examination” or “autopsy” and no “external examination” nor “inspection” nor “preliminary
examination”50.

In Switzerland, the state prosecutor orders “further examinations, if necessary an autopsy” after the
legal inspection, if “signs for a homicide are found”51, but also if there are doubts or the manner of
death or the identity are still unknown [19]. Indications for an autopsy by the pathologists include for
example: road accidents, work place related deaths, medical malpractice, (suspected) homicides,
possible relation between preceded violence and death, death in custody, arrest, police custody,
nursing home or care, unknown identity, death on railways, in water or burned bodies, death in drug,
red light or prostitution milieu [19, 32]. The relatives or everybody who is actually concerned by the
state prosecutor’s autopsy decision can file his objection (Article 393 SCCP) and further his appeal
(Article 398 f SCCP) to the autopsy [19].

Each Australian state and territory knows an autopsy (or postmortem) regulation in its Coroners Act52.
The senior next of kin has the opportunity to object or to ask for reconsideration by the coroner, mostly
within 48 hours, and after the written autopsy decision the right to appeal versus the coroner’s
direction, mostly within 48 hours, at the Supreme Court according to the Coroners Acts of all states
and territories [26]. In QLD the coroner has just to consider the concerns raised by a family member
and has to give a copy of his decision, which can be appealed at the Supreme Court. There are no
specific regulations about objection or appeal to an autopsy under the Coroners Act of SA53.

While in Switzerland the state prosecutor has to decide whether he shall charge somebody for a
criminal offence or to close the proceedings55, the coroner in the Australian states and territories can
hold an inquest, which is a court hearing about the circumstances surrounding a death (in about 5 %
of the reported cases)56. An inquest can be mandatory in case of (suspected) homicide, deaths in care
or custody or unknown identity56 [26-29]. A decision to initiate an inquest (or not), or to reopen an
inquest as well as the findings of a coroner can be the subject to appeal at the supreme court of the

47 Sect 88 f Coroners Act 2009 NSW
48 Sect 19 Coroners Act 2003 QLD
49 Sect 22 Coroners Act 2003 SA
50 Sect 20 Coroners Act NT, Sect 36 Coroners Act 1995 TAS, Sect 34 Coroners Act 1996 WA
51 Article 253 Sect 2 Swiss Code of Criminal Procedure
52 Sect 21, 71 (death in custody) Coroners Act 1997 ACT, Sect 88, 89 Coroners Act 2009 NSW, Sect 20 Coroners
53 Objection to or reconsideration of autopsy: Sect 24, 28 Coroners Act 1997 ACT, Sect 96 Coroners Act 2009
NSW, Sect 23 Coroners Act NT, Sect 19 Coroners Act 2003 QLD, Sect 38 Coroners Act 1995 TAS, Sect 26
Coroners Act 2008 VIC, Sect 37 Coroners Act 1996 WA; Appeal at the Supreme Court: Sect 90 in ACT, Sect 97 in
NSW, Sect 21 in NT, Sect 19 in QLD, Sect 37 in TAS, Sect 79 in VIC, Sect 36 in WA
54 Articles 319, 324 f Swiss Code of Criminal Procedure
55 In Victoria according to the Coroners Court Victoria, Australia
56 Sect 34 Coroners Act 1997 ACT, Sect 21,23,27 Coroners Act 2009 NSW, Sect 34 Coroners Act NT, Sect 27
2008 VIC, Sect 22 Coroners Act 1996
relevant state or territory. The decision of a Swiss state prosecutor to charge somebody cannot be objected or appealed. Finally, the coroner has to take his or her findings, with or without an inquest, and can make recommendations about matters connected with the death concerning public health and safety to relevant administrative or government bodies. If the coroner or the state prosecutor is satisfied that it is no longer necessary to have control of the body, for example because the coroners finished his or her investigation or the coroner/ state prosecutor has determined that the death was not reportable (or reviewable) or no criminal (or civil) offence is suspected i.a., the body can be released according to the relevant regulation.

c) Virtopsy and pm forensic imaging in Australian and Swiss legislation:

Nowhere is the term “Virtopsy” regulated by law. Like mentioned above, only a few literature and some court decrees mention pmCT (or pmMRI or photo grammmetry/3D surface scan) as means of evidence in coronial inquests or criminal trials (or civil trials). However no court decree discusses Virtopsy/pm forensic imaging in detail. There is no precedent court decree or leading case to these questions arising about forensic imaging. Some statutes or codes, e.g. in the USA, regulate the use of Radiographs or X rays for death investigation, usually for identification purposes. The Coroners Act 2009 NSW regulates in its Sect 88 ‘radiological examination’ as least invasive procedure, i.e. less invasive than an autopsy. Radiological examination may include CT and MRI. To the best of the knowledge of the writer Sect 3 of the Coroners Act 2008 VIC is the only regulation which includes imaging of the body and pmCT and pmMRI worldwide explicitly. For all other coroners acts, codes of criminal procedure etc. a legal interpretation is necessary. For that purpose, the relevant legal interpretation rules and acts have to be considered: For Swiss legal interpretation the literal, historic, systematic, teleological (purposive) rules; for Australian legal interpretation the relevant interpretation acts of the states and territories, and above all the purposive approach as well as still “literalism”, like e.g. term “means” is exhaustive and closed, compared to the open term “include”.

According to the relevant interpretation rules, no problems crop up to include Virtopsy/pm forensic imaging involving pmCT, pmMRI, 3D surface scan, pm CT angio and pm biopsy under the regulations about autopsy or postmortem examination (as well as further examinations or investigations or studies or tests etc.) of the different jurisdictions, including Australian states and territories, Switzerland, Germany, Austria or the states in the US as examples. Focused on Australia and Switzerland, Virtopsy/forensic imaging finds its legal base as an ‘autopsy’ or ‘postmortem examination’ under the

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58 Article 324 Sect 2 Swiss Code of Criminal Procedure
59 e.g. Article 253 Sect 2 SCCP (release of the body after legal inspection), Article 253 Sect 3 SCCP (retain or release the body depending on the necessity for the purpose of investigation); Sect 101 Coroners Act 2009 NSW, Sect 26 Coroners Act 2003 QLD, Sect 47 Coroners Act 2008 VIC
60 See 3. a) Introduction, p. 6; e.g. R v Ferguson [2007] NSWSC 949, Supreme Court New South Wales, 27 August 2007; Krantz v Hand [199] NSWSC 432, Supreme Court New South Wales, 23 April 1999; Coronial finding into death with inquest, Coroners Court Victoria, 2715/09, 8 December 2010; Coronial finding into death with inquest, Coroners Court Victoria, 3109/10, 6 June 2011, among many others; unpublished court decrees of the district courts in the cantons Bern and Aargau
61 e.g. Articles 49.01, 49.10, 49.25 of the Texas Code or Sect 27521 California Code
62 Sect 88 Coroners Act 2009 NSW
63 Sect 3 Coroners Act 2008 VIC
64 Acts Interpretation Act 1901 Cth (e.g. Sect 15 AA: Regard to be had to purpose or object of Act; s.15 AB Use of extrinsic material in interpretation of an Act); Legislation Act 2001 ACT (e.g. Sect 138, 139 f: Interpretation best achieving Act's purpose); Interpretation Act 1987 NSW (e.g. Sect 33, 34, purpose, extrinsic material); Interpretation Act NT (e.g. Sect 62A, 62 B purpose, extrinsic material); Acts Interpretation Act 1954 QLD (e.g. Sect 14 A, 14B, purpose, extrinsic material); Acts Interpretation Act 1915 SA (e.g. Sect 22 f purpose); Acts Interpretation Act 1931 TAS (e.g. Sect 8A, 8B purpose, extrinsic material); Interpretation of Legislation Act 1984 (e.g. Sect 35, 38 purpose, extrinsic material); Interpretation Act 1984 WA (e.g. Sect 18, 19 purpose, extrinsic material)
However, there is need to use Virtopsy/pm forensic imaging as a triage for and not only as an adjunct to autopsy. The probability of a mistaken judgment or finding may increase if only an external examination of the body is made. Not only pathologists or forensic experts, but also coroners and criminal judges are aware that an external examination alone is not an exact examination, i.e. often the cause of death as well as the manner of death, natural or unnatural, e.g. possible homicides, cannot be determined [2, 3]. The addition of Virtopsy/pm forensic imaging at the stage of external examination/inspection improves the determination of the cause and manner of death and detection of (disguised) homicides or medical malpractice substantially. It increases the legal security. The non-invasive imaging and the minimally-invasive procedures such as pm CT angio and pm biopsy if necessary allow the pathologist to provide the coroner or the state prosecutor with much broader and more depth information at an early investigation stage and before his or her autopsy decision. Virtopsy/pm forensic imaging allows an external view in the interior of the body to document injuries, foreign material etc. and without a dissection in the case of the non-invasive pm forensic imaging [1-11]. It facilitates the communication with the family of the deceased and on the other hand the autopsy decision itself. Virtopsy/pm forensic imaging meets the attitude of the relatives, i.e. the next of kin would appreciate such procedures to get more precise information about the death of his or her loved one and at the same time to save his or her religious (e.g. Jewish, Islamic) or cultural ideals [2, 3, 11]. Often, Virtopsy/pm forensic imaging can avoid an autopsy and objections, appeals, and associated legal procedures to it and above all their cost. Because of these reasons it is necessary to perform Virtopsy/pm forensic imaging (at least the cheapest and most practical pmCT) during an inspection/external examination in each case. Do the jurisdictions of Australia and Switzerland provide a legal basis for such a purpose?

First, the reader has to be aware how an inspection can be qualified, before an interpretation of the relevant acts is possible. An inspection involves usually a detailed external examination of a body after death including a review of medical and police reports. The inspection can include further sampling of body fluids and dental examinations, molecular biology (DNA) testing and it depends on the practice toxicological tests of the sampled body fluids [17, 18, 19, 32]. Like described above not each legislation regulates explicitly a ‘2 step’ death investigation procedure involving an inspection/external examination before the autopsy decision. The Coroner's Act 2008 VIC and its preliminary examinations under Sect 3 and 23 is a good example of such a ‘2 step’ investigation including imaging of the body such as pmCT and pmMRI: “the imaging of the body including the use of computed tomography (CT scan), magnetic resonance imaging (MRI scan), x-rays, ultrasound and photography;....and any other procedure that is not a dissection, the removal of tissue or prescribed to be an autopsy” [66]. In the Victorian practice, pm CT angio has been performed before the autopsy decision with the coroner's consent. For a pm CT angio a little dissection is necessary to reach the arteries and veins to inject the contrast agent with a certain pressure to display the vessel system and get further information about injuries, like haemorrhages [1-3]. A pm fine needle biopsy serves to get tissue out of the body for histological or toxicological examination. These examinations are obviously less invasive than a full or partial autopsy. However, the definition of the preliminary examinations in Sect 3 of the Coroners Act 2008 VIC does not allow a dissection, which is necessary to perform a minimally-invasive pm CT angio. Furthermore, tissue sampling, e.g. by pm biopsy, is excluded as well. David Ranson noticed that it "would be interesting to see whether, over time, the procedures permitted in a preliminary examination are extended to include minor biopsies of the skin or the collection of biopsy tissue for direct diagnostic purposes by means of minimally-invasive techniques such as fine needle aspiration or endoscopic biopsy" [22]. If the forensic experts of the VIFM and the relevant authorities would qualify such minimally-invasive procedures as necessary in the daily routine of preliminary examinations, Sect 3 of the Coroners Act 2008 VIC would need an amendment. For each non-invasive Virtopsy/pm forensic imaging procedure like pmCT, pmMRI or 3D surface scan, but also ultrasound, Micro CT or Micro MRI or other future non-invasive methods Sect 3 of the Coroners Act 2008 VIC provides a legal base.

One significant, if not the most significant, Australian case law in relation to Virtopsy/pm forensic imaging is a Supreme Court decision in NSW from 23 April 1999. The Supreme Court upheld an appeal versus a coroner’s autopsy decision on a 86 years old Jewish woman, who deceased under non-suspicious circumstances in her bathtub at home and declared that an external and radiological

65 Sect 21,71 in ACT, Sect 88, 89 in NSW, Sect 20 in NT, Sect 19 in QLD, Sect 22 in SA, Sect 36 in TAS, Sect 3, 25 in VIC and Sect 34 in WA
66 Sect 3 Coroner's Act 2008 VIC
examination of her would be reasonable and a forensic autopsy is not necessary. This decision can be seen as a kind of starting point of the Section 88 under the Coroners Act 2009 NSW: “...if more than one procedure is available to a person conducting a post mortem examination to establish the cause and manner of a deceased person's death ... to use the least invasive procedures that are appropriate in the circumstances. Without limiting subsection (2), examples of procedures that are less invasive than a full post mortem examination of the remains of a deceased person include (but are not limited to) the following:(a) an external examination of the remains,(b) a radiological examination of the remains,(c) blood and tissue sampling,..." [35]. Under that Sect 88 of the Coroners Act 2009 NSW it is possible that the forensic pathologist could perform a pmCT, pmMRI, 3D surface scan and any non-invasive pm forensic imaging as well as minimally-invasive pm CT angio and pm biopsy, which are less invasive than a full autopsy (postmortem examination). After reporting the results, the coroner could balance the different (legal) interests, the medical results and family concerns analogue to the practice in VIC, before he can order an autopsy if necessary.

In the eyes of the writer, the coroners acts of ACT, NT, QLD, SA, TAS, WA would need an amendment to order and perform a Virtopsy including 3D surface scan, pmCT, pmMRI, pm CT angio or pm biopsy on the early stage of an inspection and before the autopsy decision by the coroner. Because they do not explicitly regulate a '2 step death investigation' like in VIC, i.e. an inspection or preliminary examinations before the coroner's autopsy decision, nor Virtopsy/pm forensic imaging of the body including pmCT and pmMRI is explicitly mentioned in these acts.

In Switzerland, Article 253 Sect 1 SCCP provides a '2 step death investigation' and involves a 'legalinspection' before the autopsy decision of the state prosecutor. According to the Swiss legal interpretation rules and Article 197 SCCP, which implies to use the least invasive examination method, non-invasive 3D surface scan as well as pmCT, pmMRI or other imaging tools could be used during the legalinspection. On the other hand, the minimally-invasive pm CT angio and pm biopsy are more invasive techniques than the most invasive examination during a legalinspection, i.e. taking bodily fluids like blood and urine. For that purpose, an injection, but no dissection or tissue removal is necessary (and no contrast fluid is pumped through the whole body) [19, 32, 33]. For such minimally-invasive procedure an amendment would be necessary. Again it is dependent on the need of the forensic experts and legal authorities and, last but not least, financial funding. Compared to VIC (and Australia in general) the criminal focus of Swiss death investigation might influence the need for the introduction of minimally-invasive procedures as well.

d) Excursus: legal side of clinical forensic imaging

Besides Virtopsy/pm forensic imaging for pathology departments, clinical forensic imaging might play an important role in clinical forensic medicine in future. The clinical forensic physician can either use existing CT or MRI images of injuries made by duty clinical doctors in hospitals or he can perform a CT or MRI or a 3D surface scan by him/her-self (which probably covers his or her forensic issues in a better way). The clinical forensic physician documents injuries of victims or other persons using a CT or MRI scan for internal injuries, e.g. above all traffic related injuries (e.g. CT for bone injuries, MRI for soft tissue, bone bruises i.a.); choking victims/survived strangulation (CT for laryngeal bone injury, MRI for soft tissue lesion, hemorrhages), gunshot injuries and stabbing or blunt force trauma incidents (CT for bullet (particles), wound channel, gas embolism, entrance and exit wound; MRI for wound channel, soft tissue lesions, intracranial injuries i.a.) etc. or medical malpractice (CT for organ lesions, gas embolism, foreign body detection; MRI for cerebral status, hypoxia, organ lesions), and 3D surface scan to match patterned injuries at the body surface [1, 2]. A performance of a CT or MRI on a suspect may show e.g. above all foreign material like drugs in 'body-packing' cases, bullets in (police) shootings or identification of the suspect or internal examination of defensive wounds. A 3D surface scan can match foot, fist or shoes, instruments like a baseball bat or other weapons very precisely to the injuries of the victim [1, 2]. Above all MRI in survived strangulation cases is suited for extending the objective basis for the assessment of the danger to life (above all, if the other known objective sign, petechial hemorrhages has been disappeared). Hemorrhage seen at MRI in close proximity to the critical neck structures are believed to prove forcible compression and therefore to indicate a high probability of cerebral hypoxia and a life-threatening situation for the victim during the act [2, 3, 13, 14].

According to the Swiss Federal Supreme Court such a life threatening strangulation is qualified as a offence endangering of life, for which the offender can be convicted for 5 years imprisonment.

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67 Supreme Court NSW: Krantz v Hand, NSWSC 432 (23 April 1999)
68 Sect 88 Coroners Act 2009 NSW
69 Article 253 Sect 1 Swiss Code of Criminal Procedure
70 Article 197 Swiss Code of Criminal Procedure
(instead of max 3 years imprisonment for a common assault if a life danger cannot be proven)\(^71\). There is already at least one Swiss court decision which is lying back only on MRI images as forensic evidence to prove the danger for the victim’s life\(^72\) [3]. Also in other cases, e.g. shotgun or stabbing cases, clinical forensic imaging can establish a life danger, which can be important in criminal trials\(^73\).

Literature on clinical forensic imaging is rare, legal literature almost non-existent. The forensic physician needs to obtain a person’s informed consent before he or she undertakes any medical procedure including clinical forensic imaging. This applies where the examination would benefit the person (e.g. usually victim) as well as vice versa (e.g. usually suspect). Without obtaining informed consent, the physician may be subject to a civil or even criminal law action (e.g. assault) [36]. In Switzerland Article 10 Sect 2 of the constitution and Article 28 of the Civil Code regarding infringements of the personality right or physical integrity serve besides case law as legal bases for the legal construction of ‘informed consent’, In Australia, this legal issue is regulated by case law\(^74\). Sect 10 of the Charter of Human Rights and Responsibilities Act 2006 in VIC and Sect 10 of the Human Rights Act 2004 in ACT can serve as further legal bases for ‘informed consent’\(^75\). (however the charter does not create a right to start legal action for a breach of human rights, only to raise a ‘human rights argument’ for e.g. the breach of human rights by the police at the Health Service Commissioner, Office of the Public Advocate etc.). Furthermore, acts on criminal proceedings and forensic procedures provide legal bases to perform clinical forensic imaging as a technique of external examination with obtaining the suspect’s or victim’s informed consent\(^76\).

On the other hand most jurisdictions, at least in the English and German speaking world, provide legal bases in statutes or codes or case law to perform compulsory procedures during criminal investigation and proceedings. However, clinical forensic imaging is nowhere explicitly regulated by law. Therefore, a legal interpretation according to the relevant interpretation rules and acts is necessary [34]. As an approach that interpretation shows legal bases to use clinical forensic imaging on a suspect without consent and by order of the state prosecutor respectively, senior police officer for non-intimate body areas or by a magistrate as followed:

In Switzerland, Articles 241, 249, 250 SCCP for compulsory examinations of the body surface including body cavities may include 3D surface scan and Articles 241, 251, 252 SCCP for compulsory medical examinations of the body can include CT and MRI. In Australia similar regulations in acts of criminal proceedings or forensic procedures provides a legal basis for clinical forensic imaging. In most states and territories clinical forensic imaging can be qualified – following the purposive rule- as a technique of an external examination on a suspect (or if this interpretation is too extensive an amendment would be needed)\(^77\). In VIC a compulsory procedure means the taking of an intimate or non-intimate sample or the conduct of physical examination\(^78\). Clinical forensic imaging by CT, MRI or

\(^{71}\) Decrees by the Swiss Federal Supreme Court, Criminal Chamber, BGE 124 IV 53 E. 2; BGr. 6P.127/2005, 65.402/2005 i.a.

\(^{72}\) Decree by the District Court Berner Jura Seeland, Criminal Chamber, Biel, Switzerland

\(^{73}\) E.g. a stabbing case at the Institute of Forensic Medicine Bern, in which CT images has proven a life danger for the stabbing victim

\(^{74}\) Family Court of Australia, 3/5 1989, Re Elizabeth, No. S2439 of 1988, P.29: 29. It is clearly established in the common law that medical treatment without consent (implied or express) is a battery and unlawful

\(^{75}\) Sect 10 of the Charter of Human Rights and Responsibilities Act 2006 in VIC and Sect 10 of the Human Rights Act 2004 in ACT; Civil and Administrative Tribunal, 23 April 2009, Kracke v Mental Health Review Board & Ors (General) G605/2008

\(^{76}\) Sect 23 WA, WD (suspect), 23 XWQ (victim) of the Crimes Amendment (Forensic Procedures) Act 1998 Cth, Schedule 1; Sect 6, 7, 19 (suspect), 79 f (victim) of the Crimes Forensic Procedures Act 2000 ACT; Sect 7 f (suspect), s. 76 f (victim) of the Crimes of Forensic Procedures) Act 2000 NSW; Sect 448 f of the Police and Responsibilities Act 2000 QLD; Sect 3, 23 f (suspect), 8 (victim) of the Criminal Law (Forensic Procedures) Act 2007 SA; Sect 3, 9 f (suspect), 29 (victim) of the Forensic Procedures Act 2000 TAS; Sect 464 R(2) (a) (suspect), 464 ZGB (victim) Crimes Act 1958 VIC; Sect 74, 75 (body surface), 76 (body interior.. including the use of X-rays, ultrasound or similar means’), 91 (suspect), 79 f (victim)


\(^{78}\) Sect 464 SA(1), 464 (2) of the Crimes Act 1958 VIC
3D surface scan is such a physical examination, at least since photographs are seen as physical examination [37]. Therefore, in VIC clinical forensic imaging can be ordered by a senior police officer (sergeant or above) for non-intimate body parts, a magistrate by court order for the whole body of a suspect [37].

Article 251 Sect 4 SCCP even provides a legal base to perform compulsory medical examination without informed consent on victims and other involved persons, if they do not cause particular pain or threaten health and if they are necessary to solve a criminal offence according to a closed list of heavy crimes including e.g. serious assault, rape, robbery etc [19-21, 30, 31]. In Australian states and territories no medical examination including clinical forensic imaging is allowed to be used against the will of a victim or other involved person, except a given informed consent is withdrawn [37]. In such cases the police can apply for a court order [37]. Further the Criminal Investigation Act 2006 WA under Sect 83 f, 89 allows a police officer to apply for a Forensic Procedure warrant at a Magistrates’ Court for involved persons [81]. In conclusion clinical forensic imaging by CT, MRI or 3D surface scan or other non-invasive imaging methods may be performed either with the person’s informed consent or qualified as an external examination or a compulsory procedure without informed consent on a suspect, but usually not on a victim [82] [37].

e) Virtopsy/forensic imaging and evidence law: an approach

Virtopsy/forensic imaging in evidence law, above all in criminal trials, involves important questions such as:

1. the qualification of its images as a type of evidence, e.g. as “documentary evidence” under the Uniform Evidence Law in Australia [83] [38]. Under Australian Uniform Evidence Law in the Commonwealth (and ACT), NSW and VIC (and in a lesser extent in TAS and Norfolk Island) provides a broad definition of a document, which means any record of information and includes [38]:

(a) anything on which there is writing; or (b) anything on which there are marks, figures, symbols or perforations having a meaning to persons qualified to interpret them; or (c) anything from which sounds, images or writing can be reproduced with or without aid of anything else; or (d) a map, plan drawing or photograph [84] [38].

Or in Switzerland as “Beweisgegenstand” (“object of evidence”) or “Augenscheinsgegenstand” (“object of judicial inspection”) under Articles 192, 193 Swiss Code of Criminal Procedure” [19-21].

Or under Rule 1001 of the US Federal Rules of Evidence as “writings and recording or photograph”, which rules are adopted by most of the 50 states, e.g. under the Florida Statutes “90.951 Definitions (1) “Writings” and “recordings” include letters, words, or numbers, or their equivalent, set down by handwriting, typewriting, printing, photostating, photography, magnetic impulse, mechanical or electronic recording, or other form of data compilation, upon paper, wood, stone, recording tape, or other materials. (2) “Photographs” include still photographs, X-ray films, videotapes, and motion pictures [85] i.a.

2. of its presentation in court, which means that the images have to be admitted as an “image folder” including a report. However, this exhibit needs further explanation by an expert testimony [39]. An expert for Virtopsy/forensic imaging should be an experienced forensic radiologist or necroradiologist, i.e. either a clinical radiologist after obtained an additional forensic education or a pathologist after a (re)training in reading Virtopsy/pmCT/pmMRI etc. images, because clinical and forensic radiology are not the same [3]. In this context, it is necessary to analyse the relevant expert evidence rules [39]. For example, in Switzerland the rules about expert evidence in criminal trials are implied in the Swiss Code of Criminal Procedure (SCCP), Articles 182 f. The criminal trials in Switzerland are inquisitorial, i.e. that the court is actively involved in investigating the facts of the case (Article 6 SCCP: inquisitorial principle: “Penal authorities (State prosecutors and criminal courts) have to clear all for the judgment of the offence and the accused person necessary facts of the case ex officio”) [19-21].

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79 Sect 464 R(2) (c), 464 SA (senior police officer); Sect 464 R (2) (b), 464 T (3) & 464 V (5) Crimes Act 1958 VIC
80 Article 251 Sect 4 Swiss Code of Criminal Procedure
81 Sect 83 f, 89 of the Criminal Investigation Act 2006 WA
82 E.g. Sect 79 f of the Crimes Forensic Procedures Act 2000 ACT; Sect 76 f of the Crimes (Forensic Procedures) Act 2000 NSW; Sect 7 of the Criminal Law (Forensic Procedures) Act 2007 SA i.a.
83 Sect 47 f of the Evidence Acts 1995 Cth (and ACT), 1995 NSW and 2008 VIC
84 E.g Sect 38 Interpretation of Legislation Act 1984 VIC
85 Florida Statutes, Title VII Evidence, Chapter 90 Evidence Code, 90.951 Defintions
86 Article 6 Swiss Code of Criminal Procedure
prosecution and criminal courts (trial and appeal courts at cantonal level (district or county court; canton or superior Court), Federal Supreme Court at national level) call one or several experts in, if they are not equipped with sufficient knowledge and skills, that are necessary for the finding or judgment of the facts and circumstances of the case (Article 182 SCCP) [19-21, 30, 31]. Such experts have to possess special knowledge and skills in the area of expertise concerned. They have to give expertise to the best of their knowledge and conscience and according to the rules of their science, skills or profession [19-21, 30, 31]. The expert is a kind of “assistant” of the state prosecutors and the criminal courts in Swiss Criminal Procedure [19-21, 30, 31]. Private learned knowledge or skills by the state prosecutor or judge cannot replace the special knowledge or skills of the expert [19-21, 30, 31].

The expert has to be completely impartial and (legally) independent, like a judge or state prosecutor (Article 56 SCCP). That is a difference to the common law states like Australia or USA, where the criminal trial is adversarial, i.e. the court does not investigate, but is a kind of referee between the prosecution and the defense. Therefore, only the both parties mandate an expert. In Switzerland an independent and impartial forensic expert, mostly from a forensic institute, is asked by the state prosecutor or the court to give expert evidence, which can include Virtopsy/forensic imaging. The defendant or his defense attorney may mandate a (forensic) expert, e.g. a forensic radiologist for Virtopsy/forensic imaging, on their behalf and funding. No rules regarding such a „private“ expert evidence can be found in the Swiss Code of Criminal Procedure and the court has to take it in account as a claim of the defendant, but to considerate it freely [19-21, 30, 31].

The common law knows five expertise rules, the expertise rules, the area of expertise rule, the common knowledge rule, the basis rule and the ultimate issue rule [39]. In Australia, these rules apply in NT, QLD, SA and WA criminal courts-especially if there is a jury (In Switzerland there a no jury trials today). In the other Australian states and territories, including the Commonwealth and ACT, NSW, VIC, to a lesser extend in TAS and Norfolk Islands, the ultimate issue rule and the common knowledge rule have been abolished under the Uniform Evidence Law (e.g. Sect 80 Evidence Act 2008 VIC) [38, 39].

The expert evidence and testimony by a forensic pathologist or radiologist about Virtuosì/pmCT/pmMRI etc. images must satisfy the expertise, the area of expertise rule and the basis rule and the exclusion of the opinion rule under Sect 79 of the Evidence Act 1995 Cth, Evidence Act 1995 NSW or Evidence Act 2008 VIC [38, 39]: If a person has obtained specialised knowledge based on the person’s training, study or experience, the opinion rule does not apply to evidence of an opinion of that person that is wholly or substantially based on that knowledge [38 39].

The US Federal Rules of Evidence in Rule 702 f (which is adopted in most states) qualify an expert as followed: ‘If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise, if (1) the testimony is based upon sufficient facts or data, (2) the testimony is the product of reliable principles and methods, and (3) the witness has applied the principles and methods reliably to the facts of the case.’

3. of its acceptance and admissibility as evidence in courts, above all in criminal courts under the standard of proof beyond reasonable doubt. Basically, Virtopsy or CT or MRI etc. images qualified as documentary evidence (or an ‘object of judicial inspection’ in Switzerland) can be filed as exhibits at a court and presented under the relevant expert rules during an expert testimony in court, if they are relevant to prove the facts of the case and do not fall under the exclusionary rules. Under these rules it must be also discussed if convincing 3D images could meet the discretionary exclusion that means that a criminal court must refuse Virtopsy/pmCT, pmMRI etc. images its probative value would be outweighed by the danger of unfair prejudice to the defendant [39]. At first view, the 3D images should not be excluded, because the high probative value outweighs the danger of unfair prejudice and it must be also considered that crime scene or “bloody” autopsy photos probably influence a jury or a court even more to get in the danger of an unfair prejudice than precise 3D images and a report on them. However, their relevance as evidence and their completeness to be accepted depends on:

- the circumstances of every single case,
- on the jurisdiction,
- on the type of court trial: e.g. inquisitorial criminal trial in Switzerland involving the principle of free consideration of evidence and evidence standard “on the state of science and experience” [19-21, 30, 31], or inquisitorial coronial inquest in Australia not bound at evidence rules and under the standard of

87 Rule 702 of the US Federal Rules of Evidence
proof on the balance of probabilities on the sliding Briginshaw scale\textsuperscript{88} [26], or adversarial criminal trials in common law countries like Australia under the standard of proof beyond reasonable doubt or civil trials under the standard of proof on the balance probabilities in Australia respectively, free consideration of evidence under the Swiss Code of Civil Procedure,

- in the case of a criminal trial whether the accused is charged for a homicide (e.g. murder, manslaughter) or for an assault, battery (causing injury),

- whether the Virtopsy, pmCT, pmMRI etc. images are used as adjunct to autopsy results in death investigations or a ‘non-/minimally-invasive Virtopsy report’ without autopsy, but including toxicological and histological results is provided, among other factors.

In general, CT or MRI or 3D surface scan images as clinical forensic evidence might be accepted in criminal (and civil) trials, because CT and MRI are established medical examinations since decades. Of course, for every case CT or MRI images are only a part of the clinical forensic evidence which includes other examinations like external or toxicological examination and review of police and other reports etc. Forensic expert evidence based on Virtopsy/pm forensic imaging and autopsy and other examinations such as histology, toxicology i.a., seems to be accepted and might provide an exhibit on a high probative value level depending on the circumstances of the case in coronial inquests, civil trials and even in criminal trials beyond reasonable doubt in common law countries or according to the “state of science and experience” in Article 139 SCCP. However, the acceptance of Virtopsy/pm forensic imaging as complete and relevant forensic expert evidence in a coronial inquest (or civil trial) or even more on a (suspected) homicide in a criminal trial without a supplement by autopsy results depends on the circumstances of every case. As an example, evidence by Virtopsy/pm forensic imaging without autopsy results (but including other examinations like toxicology, histology etc.) may be rather accepted by (criminal) courts in a traffic related death (trauma) than in complex forensic cases, e.g. a death caused by a dozen of stabbing wounds. Furthermore, standards or principles like the ‘state of science and experience’ (Article 139 SCCP) or ‘empirical tested, subjected to peer review and publication, shows a known or potential error rate and is generally accepted by a relevant scientific community’ (Daubert Standard)\textsuperscript{89} have to be satisfied if a forensic expert provides evidence based on Virtopsy/pm forensic imaging and other examinations but without autopsy results. At the bottom line, the judge is the ‘gatekeeper’ and decides finally whether expert evidence based on Virtopsy/pm forensic imaging (without autopsy results) is relevant for the facts of the case and may be accepted under the relevant expert evidence rules and standards (of proof). That might be rather the case in Australian coronial inquests, in which the coroner is not bound at such expert evidence rules and the standard of proof is on the balance of probabilities, as well as in civil trials, and perhaps even rather in Swiss inquisitorial criminal trials with free consideration of evidence (and sometimes expert evidence ordered by the court it-self) compared to (adversarial) criminal trials under the standard of proof beyond reasonable doubt (in common law countries).

4. Conclusions:

Virtopsy/pm forensic imaging and its advantages must be used in modern death investigation, as an adjunct to traditional examinations like autopsy as well as a triage for the autopsy decision during an inspection or preliminary examination. There are no rejections or obstacles to qualify Virtopsy/pm forensic imaging as an autopsy or postmortem examination or further examination/investigations/test/study etc. However, different reasons like to ensure legal security (disguised homicides and medical malpractice), to satisfy religious or cultural concerns of the relatives regarding autopsy, to facilitate the autopsy decision because of a wider range and depth of information at an early investigation stage and higher acceptance by the next of kin because of the non-/minimally invasiveness highlight the additional value of Virtopsy/pm forensic imaging during an inspection (external examination) or preliminary examination and before the autopsy decision. Such a Virtopsy/pm forensic imaging practice may avoid many autopsies. Swiss, Victorian and NSW legislation (and similar ‘2 steps death investigation systems’ around the world) provide a legal base for non-invasive Virtopsy/pm forensic imaging, e.g. pmCT, pmMRI during an inspection/external examination. However, except the Coroners Act in NSW most regulations about inspections (external examinations) including the ‘preliminary examinations’ under the Coroners Act 2008 VIC or the

\textsuperscript{88} Briginshaw v Briginshaw [1938]HCA 34, (1938) 60 CLR 336 (30 June 1938): The Briginshaw scale can be defined as a standard of proof toward the criminal standard beyond reasonable doubt, i.e. the relevant act or facts have to be proved only on the balance of probabilities, but proof must be clear, cogent and exact and when considering such a proof, weight must be given to the presumption of innocence.

\textsuperscript{89} US Supreme Court, Daubert v. Merrell Dow Pharmaceuticals, 509 U.S. 579 (1993)
‘legal inspection’ under the Swiss Code of Criminal Procedure would need an amendment for the use of minimally-invasive procedures including pm CT angio and pm biopsy.

The impact of Virtopsy/pm forensic imaging should be considered for future statutes or codes or amendments of current legislation, e.g. in the Australian states and territories except VIC and NSW. An exemplary regulation for an inspection including Virtopsy/pm forensic imaging might be guided by the ‘preliminary examinations’ in the Coroners Act 2008 VIC, Sect 88, 89 of the Coroners Act 2009 NSW, the Swiss Virtopsy®-project and could be defined as followed:

(1) In the case of a reportable death the relevant authority (Coroner/Prosecutor/Police/Medical Examiner) has to authorise a forensic institution or a qualified forensic physician or pathologist to perform an inspection on the body to clear the cause, manner or circumstances of death and the identity of the deceased, before he or she decides, whether an autopsy should follow for the same purpose.

(2) An inspection of the body includes (but is not limited to):
   1. an external examination of the body including body cavities and dental examination
   2. imaging of the body (virtopsy) including CT-scan, MRI-scan, x-rays, photography, photogrammetry, surface scan, ultrasound
   3. the collection and review of information, including personal and health information, police and medical reports
   4. the taking of samples from the body surface and of bodily fluid including blood, urine, saliva and mucus from the body and testing of those samples
   5. any other least invasive procedure, which is less invasive than a partial or full autopsy, including fine needle biopsies and angiography

Moreover, acts of criminal proceedings (or forensic procedures) may serve as legal bases for clinical forensic imaging, e.g. CT or MRI, as compulsory procedure without consent of the suspect (and rarely of a not suspected person including victim). Basically, Virtopsy or CT or MRI etc. images can be used as evidence and are admissible in court. For their interpretation in court expert evidence under the relevant expert evidence rules is necessary. Supplemented by autopsy results in death cases and in general on living people, Virtopsy/forensic imaging may be accepted in court rooms under the relevant exclusionary rules and standards (of proof). Virtopsy/pm forensic imaging completed by other examinations like toxicology and histology but without autopsy results might serve as relevant and admissible evidence in specific cases. The judge as the ‘gatekeeper’ for evidence must consider the completeness, the relevance of the evidence, the exclusionary rules, e.g. the opinion rule and the relevant standards (of proof) depending on the jurisdiction and the type of trial. Finally, the reader should not forget that findings by full-invasive autopsy as well as by Virtopsy/pm forensic imaging has to be seen in the overall picture of all circumstances of the case and all the other available and admissible evidence (e.g. witnesses, videos, documents, results of crime laboratories’ examinations like ballistic of weapons or blood stains etc.).

Author and Contact:

David Zimmermann, MLaw (LLM), Phd-candidate; Bern Graduate School of Criminal Justice, University of Bern, Schanzennekstr. 1, 3001 Bern, Switzerland, Email: david.zimmermann@krim.unibe.ch, Ph: +41 78 653 67 97. Feedback more than welcome!

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