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ScienceDirect
Forensic Science International 174 (2008) 35–39
Forensic Science International
www.elsevier.com/locate/forsciint

Cadaver dogs—A study on detection of contaminated carpet squares

L. Oesterhelweg [a,b,*], S. Kröber [c], K. Rottmann [c], J. Willhöft [c], C. Braun [a], N. Thies [d], K. Püschel [a], J. Silkenath [c], A. Gehl [a]

[a] *Institute of Legal Medicine, University Medical Center Hamburg, Germany*
[b] *Center Forensic Imaging and Virtopsy at the University of Bern, Switzerland*
[c] *State Police Academy (LPS 36), Department of the Interior, Hamburg, Germany*
[d] *Police Faculty, Technical College for Public Administration, Hamburg, Germany*

Received 3 October 2006; received in revised form 24 January 2007; accepted 28 February 2007
Available online 2 April 2007

Abstract

Introduction: Cadaver dogs are known as valuable forensic tools in crime scene investigations. Scientific research attempting to verify their value is largely lacking, specifically for scents associated with the early postmortem interval. The aim of our investigation was the comparative evaluation of the reliability, accuracy, and specificity of three cadaver dogs belonging to the Hamburg State Police in the detection of scents during the early postmortem interval.

Material and methods: Carpet squares were used as an odor transporting media after they had been contaminated with the scent of two recently deceased bodies (PMI < 3 h). The contamination occurred for 2 min as well as 10 min without any direct contact between the carpet and the corpse. Comparative searches by the dogs were performed over a time period of 65 days (10 min contamination) and 35 days (2 min contamination).

Results: The results of this study indicate that the well-trained cadaver dog is an outstanding tool for crime scene investigation displaying excellent sensitivity (75–100), specificity (91–100), and having a positive predictive value (90–100), negative predictive value (90–100) as well as accuracy (92–100).

Keywords: Cadaver dogs; Search for cadavers; Early postmortem interval

1. Introduction

Search dogs (*Canis lupus familiaris*) are used and trained by a large number of law enforcement agencies and rescue teams worldwide. These dogs are able to detect the scents of illegal drugs, explosives, flammable materials, and other contraband items such as illegal imports of ivory. Specialized search dogs, some of which are commonly referred to as cadaver dogs, are trained to exclusively detect human scents of alive and deceased bodies [1–12]. The scent, associated with that of deceased individuals, such as dried blood, is generally regarded as human-specific, but its exact chemical composition is still largely unknown. Several odor analyses of putrefying bodies have been performed, but the specific odor associated with recently deceased or ''fresh'' bodies have not been sufficiently investigated [13–15]. Cadaver dogs do not only signal upon finding putrefied human tissue or old remnants of blood, they further signal when detecting a recently deceased body [15]. Generally, cadaver dogs do not give specific signals when recognizing the scent of living individuals [7]. Artificial scents containing putrescine and cadaverine are commercially available; but these substances have not been established as the single most relevant odor in the scent of deceased human tissue. These substances are also present in all decaying organic materials as well as organic materials of living individuals, e.g. their saliva [16]. So the true ''perfume of death'' is discernable and its composition important for the successful search of cadaver dogs. However its components remain a mystery and largely unidentified. There have been few studies performed that focus on the reliability of cadaver dogs with varying skills

* Corresponding author at: Center Forensic Imaging and Virtopsy at the University of Bern, Institute of Forensic Medicine, Bühlstrasse 20, 3012 Bern, Switzerland. Tel.: +41 31 631 31 35; fax: +41 31 631 38 33.
E-mail address: lars.oesterhelweg@irm.unibe.ch (L. Oesterhelweg).

0379-0738/$ – see front matter
doi:10.1016/j.forsciint.2007.02.031

and training. Most searches are performed on contaminated items stemming from a longer postmortem interval [4].

Worldwide distrust in the ability of cadaver dogs is also present amongst German law enforcement agencies and judicial entities [12]. Some pending questions in regard to a criminal case encountered by the Public Prosecutors Department in Hamburg triggered this investigation into the ability of cadaver dogs to discern scents of early postmortem tissue from more decompensated tissue. A married couple went on a sailing trip. During this trip, the wife disappeared and was reported missing by her husband. A criminal investigation was initiated and the husband was under suspicion of having murdered his wife. A cadaver dog of the State Police of Hamburg was ordered to search the yacht and gave a signal on a mattress in the bedroom of the yacht.

There were several questions by the Public Prosecutor's Department of Hamburg regarding the reliability of a cadaver dog's ability to signal correctly with a precise accuracy. A literature review produced very few studies dealing with situations similar to the aforementioned scenario: the question remained on how long deceased tissue or a deceased body have to be in contact with a material, such as the mattress, for the scent to be detectable by cadaver dogs. Furthermore, the time frame during which this scent may remain contained within the material has never been investigated.

2. Material and methods

Two deceased individuals, a 60-year-old male (A) and a 63-year-old male (B) were admitted to the Institute of Legal Medicine at the University Medical Center Hamburg. They were immediately transported to a tent placed within the inner courtyard of the institute. The location for this investigation was specifically chosen in order to minimize a potential cross contamination of any odors with those of stored, putrefied bodies within the Institute. Both men (A and B) had publicly collapsed and died despite comprehensive resuscitative efforts. At the start of our investigation, the postmortem interval for both men (A and B) was measured at 110 and 120 min, respectively. Their body temperature was measured at 37.2 °C (A) and 36.7 °C (B). Both bodies presented with a dry and intact skin without any visible injuries except a puncture site from an intravenous catheter on the posterior surface of one hand. These puncture marks were immediately covered with latex gloves to prevent a direct contamination of any materials with the dried blood.

Brand new carpet squares 20 cm × 20 cm were purchased and used as the medium for the odor transport. Before the initiation of this investigation, the carpet squares were stored in airtight containers outside the boundaries of the Institute of Legal Medicine.

The two bodies were placed in a supine position on top of a new and clean table and a separate table was used for each individual. A cotton blanket was wrapped around each body to preclude the direct contamination of the carpet squares with the bodies while at the same time simulating a thin layer of clothing covering each individual. A total of 32 carpet squares were placed subsequently underneath the backside of the torsos. Within 45 min of the arrival at the institute, 24 carpet squares (body A) were "contaminated" for 10 min during three consecutive sessions. Within 15 min of arriving at the institute, eight other carpet squares (body B) were contaminated for 2 min during two subsequent sessions. Additionally, living individuals who denied having had any contact with deceased tissues served as control subjects and contaminated an additional eight carpet squares. Immediately following the contamination, the carpet squares were placed into airtight glass jars and brought to the Police Dog Training Center (LPS 36) at the Hamburg State Police Department.

The State Police of Hamburg trains and keeps three blood and cadaver search dogs:

- "B.", Malinois, male, 7 years old, 5 years "on duty" (Fig. 1a),
- "K.", Herder, male, 4 years old, 1.5 years "on duty" (Fig. 1b),
- "L.", Malinois, female, 3 years old, 1.5 years "on duty" (Fig. 1c).

The education and training the dogs received consisted primarily of searching for "wet" materials such as blood, body fluid and muscle tissue. Generally, scratching and barking demonstrated a positive signal by the dogs, whereas negative signals produced no reaction. For this investigation, a false-positive reaction was defined by the dog's positive signaling for any uncontaminated

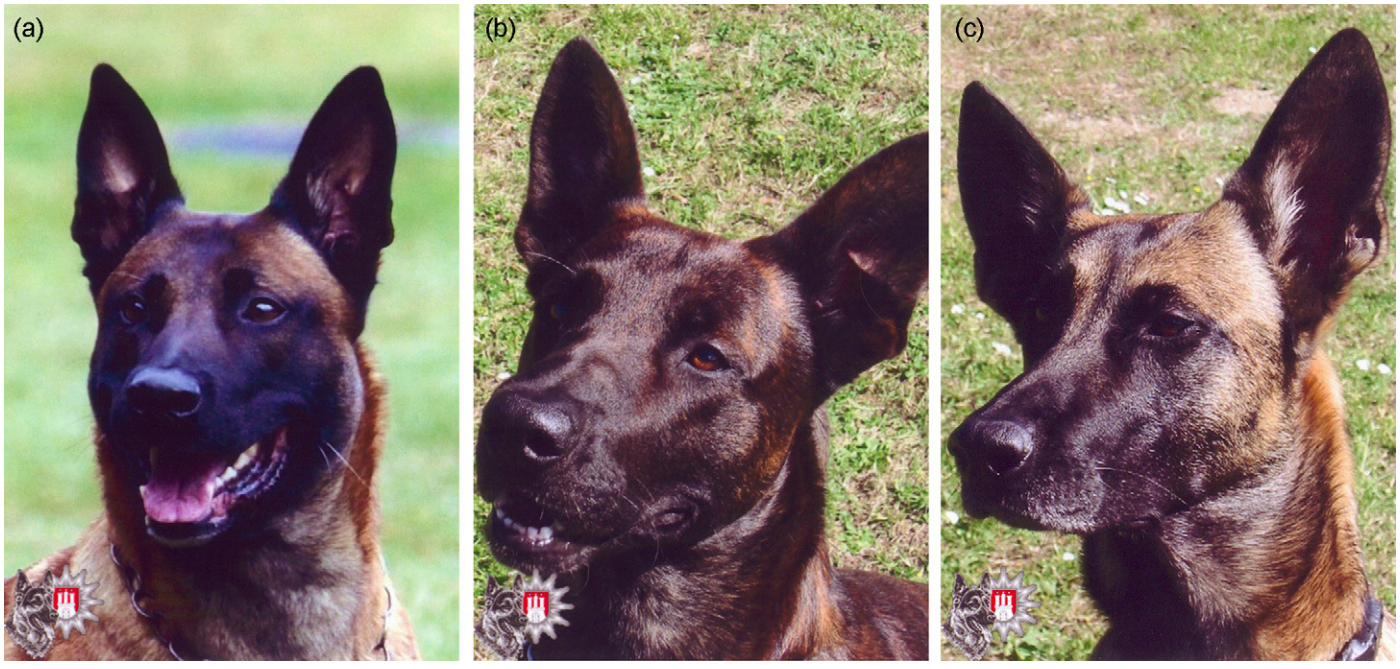

Fig. 1. (a) Blood and cadaver search dog "B.", Malinois, male. (b) Blood and cadaver search dog "K.", Herder, male. (c) Blood and cadaver search dog "L.", Malinois, female.

Fig. 2. Search situation: search dog "K." with handler and six open glass jars.

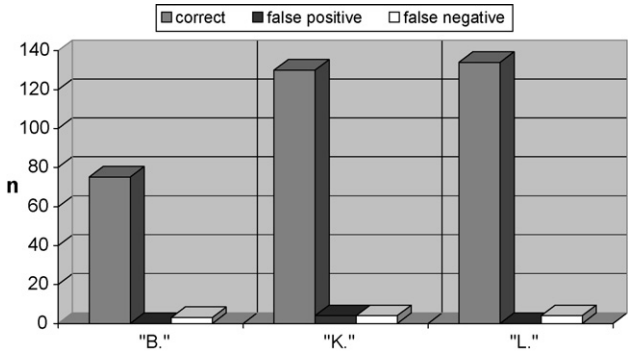

Fig. 3. Results of the cadaver dogs of the Hamburg State Police.

Table 2
Statistic values, 2 min contamination

Dog	"B."	"K."	"L."	Total
Sensitivity	75	96	75	86
Specificity	100	93	100	97
PPV	100	90	100	94
NPV	90	98	92	93
Accuracy	92	95	94	94

carpet squares while a false-negative signal was defined as the "over-running" of contaminated material without exhibiting the proper signal.

The design of this study was based on a construct of six glass jars, each containing one carpet square. The cadaver dogs were instructed to search for the contaminated square amongst these six possible choices (Fig. 2). Every sixth search was carried out without any contaminated material and at irregular intervals, carpet squares contaminated by the control subjects were added. Neither the dog nor the dog's handler observed or were aware of the position of the contaminated squares, and were further monitored by a co-handler. After the initial series of tests, the contaminated carpet squares were stored on open-air racks and utilized again for comparison searches of then time-dated materials (carpet squares). Depending on the availability of the dog/handler team, comparison searches were performed on the first day after the initial contamination and up to 35 days (carpet squares contaminated for 2 min) and 65 days (carpet squares contaminated for 10 min) post-contamination. All searches were distributed over the length of investigation with a maximal interval of 10 days in-between searches.

3. Results

In total, 354 searches were performed. Each search involved a design construct of six possible choices (contaminated or uncontaminated carpet squares). The results of these searches are demonstrated in Table 1 and Fig. 3. Searches of squares contaminated with the scent of the control (alive) subjects, ilicited no signals from any of the cadaver dogs. The results indicate that the dog's sensitivity for the detection of contaminated carpet squares was 98% for those squares contaminated for a maximum of 10 min and 86% for those squares contaminated for only 2 min. The dog's specificity was measured to be 97% for both samples of contaminated squares. The positive predictive value (PPV) was calculated to be 94% (2 min) and 98% (10 min) while the negative predictive value (NPV) was measured at 93% (2 min) and 97% (10 min). The skilled searches of the dogs resulted in a 94% accuracy for squares contaminated for 2 min and 98% for those squares contaminated for 10 min. The "interdog"-variability was low (Tables 2 and 3). The dogs largely false signaled, in the form of "over-runs" and "mis-signals" during searches performed on carpet squares (10 min) that had previously been ventilated for 5–6 days, or on carpet squares (2 min) that had been ventilated for 2 days. Nonetheless, searches performed of carpet squares

Table 1
Signaling behavior in interconnection to the time of contamination

Contamination time/signaling	"B."	"K."	"L."	Total
Uncontaminated or contaminated by living person/correct negative	26	43	46	115
Uncontaminated or contaminated by living/false positive	0	3	0	3
2 min/correct positive	9	27	12	48
2 min/false positive	0	0	0	0
2 min/false negative	3	1	4	8
10 min/correct positive	40	60	76	176
10 min/false positive	0	1	0	1
10 min/false negative	0	3	0	3
Total	78	138	138	354

Table 3
Statistic values, 10 min contamination

Dog	"B."	"K."	"L."	Total
Sensitivity	100	95	100	98
Specificity	100	91	100	97
PPV	100	94	100	98
NPV	100	93	100	97
Accuracy	100	94	100	98

that had been ventilated for longer periods of time than those aforementioned time frames were concluded without any false results by the dogs. This systemic investigation ended after 65 days due to the limited time of the dogs and dog handlers to perform regular searches. Non-scientific trial searches performed over the next several months demonstrated additional error-free runs.

4. Discussion

Much research has been conducted assessing the reliability of search dogs in identifying different materials such as explosives, flammable materials and organic tissue. While cadaver dog studies on decomposed and buried bodies or body parts are mentioned in the literature review, investigative studies dealing with the identification of tissue and other materials during the early postmortem interval are largely absent [4,5]. Our investigation provides a near realistic reconstruction of a potential crime scene by simulating a recent deposit of a thinly clothed body (cotton blanket) on a reasonably common surface (carpet).

The relevant substances in scents of human corpses are not clearly identified and hence, a confirmation of results obtained by cadaver dogs does not exist and at this time, cannot be reproduced by means of an instrumental analysis. Therefore, the designation by a dog that a deceased body has potentially contaminated a surface may be used only as a strong indicative tool during the investigative process of a homicide case. This study demonstrated the fact that only very few searches by trained dogs resulted in a false-positive signal and hence, emphasized the necessity of employing these dogs to enhance the accuracy and reliability of homicide investigations worldwide. As no other analytical confirmation is possible at this time, a positive signal by a trained cadaver dog should not be used as the sole of evidentiary piece in court. These dogs remain "only" an excellent search tool. Furthermore this investigative study produced excellent results and as Schoon [17] has already determined, conditions of an experimental design do significantly differ in many aspects from an actual crime scene. Thus, our results may not be extrapolated to all environments encountered by investigative law enforcement units.

The olfactory sense of dogs is known to be highly sensitive and allows for a near perfect discrimination of different odors [7]. Cadaver dogs are trained to identify and signal upon encountering scents associated with deceased tissue. A monosubstance scent such as cadaverine or putrescine does not initiate a positive signal by these dogs. Other components of this specific scent must be present so that these dogs give a positive signal. Our investigation was based on using scents that were obtained from individuals with a postmortem interval of less than 3 h—an interval in which some organs and many cells of the human organism are still vital and have not yet started the process of putrefaction. Hence, further research is necessary that may discern different components of scents associated with various postmortem and vitality intervals. The olfactory sense of trained dogs is highly sensitive and the dog's ability to smell seems to be far superior to the level of science today.

The reliability and accuracy of the dog's signals may be enhanced if at least two or more trained cadaver dog/handler teams are used independently and at one crime scene. The teams are then able to compare their dog's signaling behavior. This process would lend additional support during the presentation of the findings of cadaver dogs in a court of law.

Research concerned with the effects and reliability of aging and deteriorating scents that are still detectable by dogs has been performed by Schoon [10,11]. Here, the "dog" is explicitly described as "reliable enough to be a forensic tool". We concur and advocate that the trained dog/handler team should be regarded as an excellent tool for crime scene investigations and cadaver searches. In agreement with Schoon's study on the aging of scents, we could not find a decrease in the accuracy of the dog's performance. The most interesting question of all remains: that of *how long must an individual be dead for his/her scent to be detectable by a trained cadaver dog*? Answering this pertinent question was not part of our investigation, but we can point out that a postmortem interval of 2 h seems to be a safely recognizable interval for the detection of deceased tissue by trained cadaver dogs.

Acknowledgements

The authors gratefully acknowledge the Hamburg State Police for allowing us to perform this investigation with their valuable cadaver dogs. Many thanks to Basco, Kalle and Lady for their qualified and enthusiastic support of our endeavor. We are also grateful to Andrea Lambe, MS, RN for editing this manuscript.

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