



Incidence and strategies for preventing sustained hypothermia of crash victims during prolonged vehicle extrication



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ABSTRACT

Background: Vehicle extrication of crash victims is a highly-demanding challenge, due to the frequently life-threatening injuries of entrapped occupants. In this phase, crash victims are often exposed to the outdoor-temperature, with the risk of sustained hypothermia. Hypothermia can significantly raise the morbidity and mortality rates of crash victims. Therefore, we have correlated the incidence of severe car accidents with entrapped patients, the outdoor conditions, and expenditure of time for extrication. Furthermore, different warming strategies have been evaluated regarding their integrability within the rescue procedure.

Methods: To estimate the incidence of severe car accidents with entrapped patients, we performed retrospective data mining for the cold season of a three-year period in a rural district in Germany. We evaluated the integrability of a chemical heated blanket, its combined application with a forced-air warmer, or with an infrared radiator for patient warming. Therefore, we analysed the time tracking of extrication reference points during extrication exercises undertaken by the rescue services, simulating a severe vehicle accident and evaluated questionnaires administered to rescue personnel and subjects. Furthermore, we monitored subjects' physiologic parameters to estimate the warming effect.

Results: Incidence analysis resulted in extrication times of up to 80 min, representing two severely-entrapped patients per month in the cold seasons, corresponding to about four entrapments per 100.000 inhabitants every year. Of the different warming strategies analysed, the chemical blanket and the combination infrared radiator/chemical blanket were favoured regarding the items 'operator convenience', 'weight/size/handling', 'stability in positioning', 'time needed for installation', 'manpower requirement', 'hindrance during extrication operation', 'versality during extrication process', and 'robustness' by the rescue personnel; the forced-air warmer and the infrared radiator were preferred with regard to 'warming effect', the forced-air warmer and the chemical blanket was advantageous with regard to 'physical protection'.

Conclusions: Vehicle extrication procedures are time consuming, a relevant finding that provides a rationale for discussing and optimising the rescue procedure to prevent sustained hypothermia. We determined that combined application of an infrared radiator and a chemical blanket is advantageous in terms of integration into the rescue process. However, a more detailed investigation, focussing on warming efficacy, must be performed.

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Background

Vehicle extrication of crash victims is a time-critical and highly-demanding challenge, due to the frequently life-threatening

injuries of the entrapped occupants [1]. Technical equipment of the emergency rescue service for vehicle extrication of crash victims has considerably improved over recent decades. These tools include cutters, spreaders, door busters, rams and chains [2,3]. Similarly, experience and knowledge of rescue services have continually been refined by regular training [4]. Nevertheless, newer vehicle technologies and patient-oriented rescue strategies mean that the time required for extrication of crash victims has significantly increased [5,6]. According to laboratory tests,

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extrication from cars made between 1990 and 1992 took less than one hour in 80% of cases; for cars produced from 2005 to 2007, extrication took more than one hour in 50% of cases – a result of the greater structural stability of newer cars. Additional time is also necessary for preventive measures; for example, airbags that do not deploy during the accident can inadvertently be activated by extrication operations even up to 20 min after disconnection of the vehicle's battery [7].

During extrication, crash victims are often exposed to outdoor temperature [8–10]. Extrication time is therefore a risk-aggravating factor for the occupants to develop sustained hypothermia [11,12]. Hypothermia, as part of the trauma triad with acidosis and coagulopathy, can significantly raise the mortality rate of crash victims [13–20]. Different analyses of the US National Trauma Data Bank revealed, that hypothermia is after correction of confounding parameters an independent predictor of increased mortality, giving an odds ratio (OR) of 1.54 [21], resp. OR = 1.19 [22]. Consequently, special effort is required to prevent sustained hypothermia of crash victims during prolonged vehicle extrication [23]. Until now, spotlights have routinely been set up by the fire brigade to light the crash scene, but also to warm crash victims. However, halogen spotlights have been replaced with LED-driven spots, which do not emit heat in relevant amounts and so no longer provide warmth.

To estimate the relevance and risk of sustained hypothermia, we analysed the incidence of vehicle accidents with entrapped persons and determined the in-field duration time to extricate crash victims. Warming strategies must be seamlessly integrated into the extrication process and must not disturb or even delay rescue operations. Therefore, we also performed an integrability study to evaluate the practicability of different warming techniques, or combinations of those, within the rescue process performing simulation exercises. We explored the feasibility, practicability, and integrability by applying three different warming c: (1) a chemical heated blanket, (2) a specially-engineered infrared radiator, and (3) a forced-air warmer, whereby the warming effect of the IR-emitter and forced-air warmer was continued by a chemical blanket after the extrication process. We aimed to: (a) estimate the incidence of severe car accidents with entrapped victims; (b) comparatively quantify the overall rescue time for vehicle extrication when warming procedures have been integrated; (c) evaluate integration and practicability of the warming strategies within the rescue procedure as a primary endpoint of our study. Furthermore, we monitored subjects' physiologic parameters to estimate the warming effect as a secondary endpoint.

Methods

Incidence analysis

Retrospective data mining regarding vehicle extrication following an accident was performed by surveying a three-year period in a rural district in Germany (District Gütersloh, NRW), focussing on the cold season: October to April (21 months). With approx. 360,000 inhabitants, the district covers an area of nearly 1000 km²; 77% is used for agricultural or forestry activity, 21% is settlement area. Two federal motorways, as well as six state roads, pass through the county. The analysis was based on the database of the district control centre, including: (1) emergency calls reporting car accidents and claiming at least one entrapped occupant; (2) first responder's feedback, additionally requesting an extrication crew. The rescue period was defined from the timestamp of an incoming emergency call up to the statement "entrapped person extracted", which is routinely confirmed by the rescue crew leader to the control centre. Rescue operations where extrication took less than 20 min were excluded in our analysis, as heating procedures were – though relevant – but often not immediately available or not practically

applicable. For the selected vehicle accidents, the corresponding outdoor temperature at the time of the accidents was extracted from a meteorological database (www.wolframalpha.com).

Integrability study

To study the integrability of heating devices in a rescue process, close-to-reality extrication operations were simulated. In three study arms, comparable compact cars were employed to explore different heating strategies (a–c). The extrication was performed by creating a large side opening, as shown in Fig. 1.

Strategy A: During and after the extrication process, the subject's body was covered with an active self-warming blanket, giving off heat by an exothermic chemical reaction. A commercially-available, single-use, self-warming blanket, Mölnlycke Barrier[®] EasyWarm[®], was used. According to the manufacturer's specifications, the blanket is 152 × 92 cm in size and warms to 40 °C within 30 min after opening the protective cover, keeping the temperature for 10 h. Heat release is performed by twelve bags dispersed over the blanket containing, among other things, a mixture of iron powder and activated charcoal, which spontaneously oxidizes when coming into contact with atmospheric oxygen, according the following reaction:



Strategy B: During the extrication process, the subject was exposed to an infrared radiator (Fig. 2), which was engineered to meet the requirements for rescue strategies. The radiator consists of two quartz infrared halogen bulbs (Solamagic[®] 1400 ECO+, Philips HeLeN IR-bulb, Zeulenroda-Triebes, Germany), delivering 2800 W (Fig. 3). The radiator protection class meets IP 24. The radiator has a housing dimension of 46 × 34 × 20 cm, weighs 6.5 kg, and is powered by 230 V/12.2 A, AC. The radiator housing is equipped with a standard support to mount it on a tripod, which is standard equipment in the rescue vehicles. The infrared radiator was positioned 1.5 m in front of the subject. In this study arm, the subject received tinted safety glasses to protect their eyes against infrared-radiation damage during an extended exercise. After extrication, infrared warming was interrupted and instead the warming process was maintained covering the subject with a warming blanket. The chemical blanket was already activated at the beginning of the extrication operation, in order to start the heat development.

Strategy C: During the extrication process, the subject was wrapped in a forced-air warming blanket, covering the upper body (3 M[™] Bair Hugger[™] Upper Body Blanket, Model 522). The 3 M Bair Hugger[®] 750 in-house forced-air warmer consists of the warming unit with a blower and a temperature management device of 1500 W (7.2 A) power. A 3 m long flexible hose with a diameter of 12 cm conducts warmed air into a fine, perforated, lightweight air mattress. The warmed air is finely dispersed and blown over the subject's trunk. After extrication, forced air warming was interrupted, the warming measurement was instead maintained using a warming blanket, that has been activated at the start point of the extrication.

Thus, the entire extrication manoeuvre has been performed three times in succession with the respective heat method. Regional meteorological outdoor conditions at the study site have been taken from a database (www.wolframalpha.com).

Personnel: The studies were integrated into the regular training courses of the voluntary fire brigade, Gütersloh. In addition, the employed fire crew was a very experienced team, which is in addition to the regular trainings well-coordinated by numerous real tasks. During each exercise, the same volunteer was deployed in all three study arms to act as the victim. The rescue process was operated by the voluntary fire brigade and the emergency medical



Fig. 1. Large side opening and lateral bending of the roof were performed to give wide access to the patient. Here, the subject is wrapped into the lightweight air mattress.

service was performed by the municipal fire brigade (three paramedics, one emergency physician). Each study was executed by the same rescue and emergency medical team, and each member of the rescue team took the same position. To rule out a possible time advantage in the setup of the infrared heater - due to

a possible learning effect - the first exercise run was performed with the infrared heater.

Additional equipment: In preparation for the study, the volunteers was equipped with a measurement setup connected to a Draeger Infinity Delta monitoring system to record oxygen

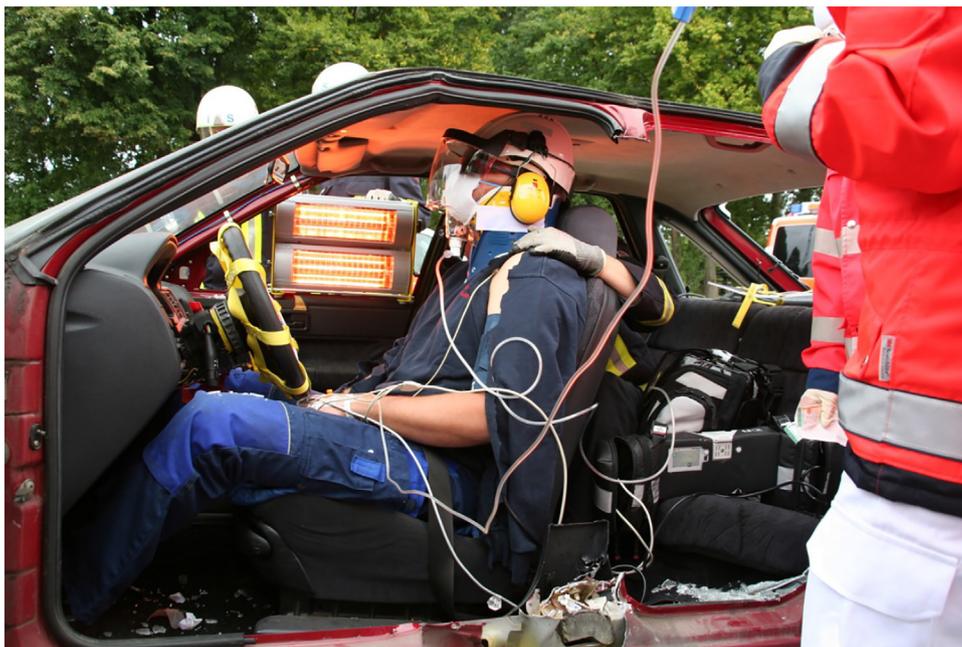


Fig. 2. Extrication process using warming strategy B (infrared radiation): lateral opening of the vehicle is accomplished (compare to time point 18 in Fig. 2) by removing B-pillar and the complete left door section, giving access to the cabin. Patient safety is ensured using safety goggles, head protection, and a dust mask, providing protection during the rescue operations. Patient monitoring (oxygen saturation, blood pressure, ECG) is applied and an oxygen mask and intravenous access administered. Airbag explosion protection is installed at the steering wheel. In this exercise, infrared radiation due to spatial hindrance is applied from the side to reduce distance to the patient.

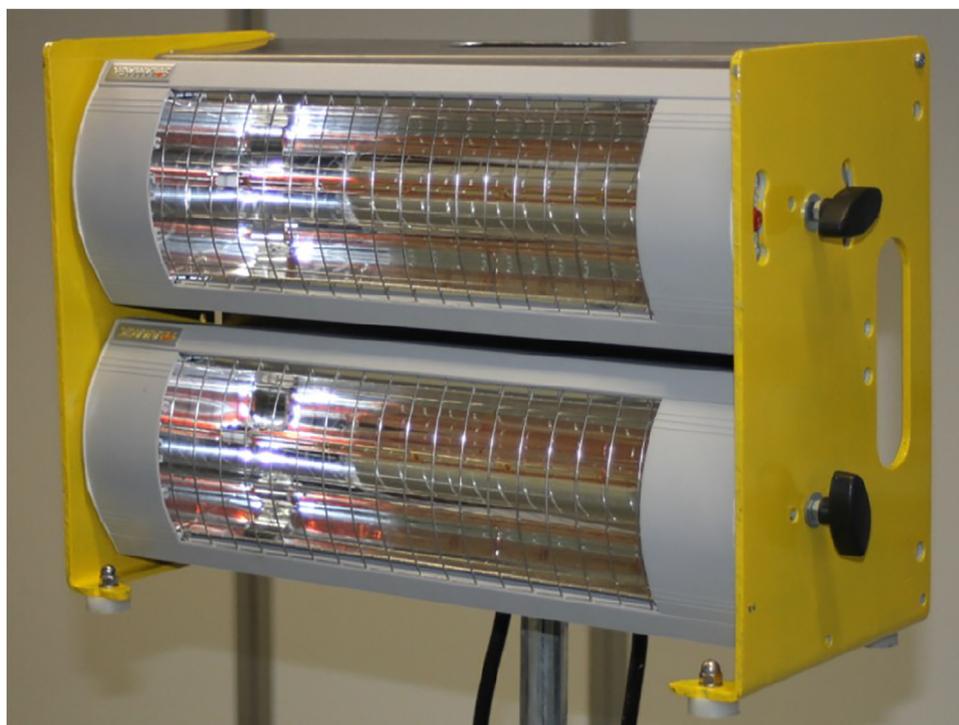


Fig. 3. Infrared radiator, engineered to meet the requirements for rescue strategies, consisting of two quartz infrared halogen bulbs, delivering 2800 W.

saturation, heart rate, and skin surface temperature at the subject's lower back.

Screenplay: In our scenario, a single-vehicle, single-occupant accident was assumed, supposing the occupant to be conscious and in a cardiopulmonary stable state. One leg was assumed to be trapped within the cabin, the right arm broken, and the subject complained of back pain. The rescue team interpreted this situation as requiring them to perform a patient-orientated, spine-preserving rescue strategy instead of rapid extrication. The extrication operation engaged a fire brigade crew (nine firefighters) who performed the extrication operation, and an emergency team made up of three paramedics and an emergency physician, corresponding to the way in which emergency medicine is organized in Germany [24]. The extrication reference points are subsequently indicated by Arabic numbers (1–25), respectively by uppercase letters (A, B, C) in parentheses, which correspond to the characters in Fig. 4.

The screenplay instructed that the ambulance and rescuing fire brigade would arrive simultaneously at the site of action (1). The emergency physician arrived about 4 min later. The following steps were performed successively or in parallel:

Step I: Exploration and protection of the accident scene should have already been done. A paramedic made contact with the subject (2). The vehicle was secured to prevent it from rolling away (3). Since the front doors were assumed to be jammed, direct access to the cabin was prevented. Therefore, a side window in the back of the vehicle was opened (4), giving access for a rescuer (commonly referred to as squirrel) to climb in and switch on the hazard lights, turn off the engine, and install airbag explosion protection at the steering wheel (5); the squirrel also makes contact with the subject (6). In parallel, rescue personnel unsealed the vehicle bonnet, using a hydraulic spreader, and disconnected the vehicle battery (7).

Step II: A member of the emergency crew entered the vehicle (8), making contact with the crash victim, performing a body check for an initial medical assessment (revealing the above-stated pattern of injuries) and applying a cervical collar (9). The subject then gets safety goggles, head protection, and a dust mask, providing protection during the subsequent rescue operations (10). All remaining windows were then broken, giving enhanced access to the subject (11). Monitoring of the subject's physiological parameters (oxygen saturation, blood pressure, ECG) and applying oxygen was started (12), and application of intravenous access was simulated by a paramedic (13).

Step III: The emergency physician repeated the body check (14), administered infusion and analgesics (15), simulated application of a second intravenous access (16), stabilised the arm fracture (17), and emphasised a spine-protecting rescue strategy. Using the hydraulic cutters and spreaders, the left B-pillar was cut, and the complete left door section removed, giving access to the cabin to stabilise the subject's simulated forearm fracture (18). Next, A- and C-pillars were cut (19), allowing the vehicle roof to be bent to the passenger side (20). Comprehensive access for extrication was accomplished (21). Cutting the seat hinges (22) allowed the backrest to be cautiously bent backwards. The subject was pulled up on a spine board (23), extricated from the vehicle and brought into the ambulance car (24), whereby the study ended (25).

In study arm I (chemical blanket), the self-warming chemical blanket was activated (A) and applied after opening the front door window (B). The chemical blanket remained on the subject during the complete rescue operation (25).

In study arm II (infrared radiator-induced warming), the infrared-radiator was positioned in front of the car (C) and adjusted to the subject's upper body after the vehicle's battery was disconnected (D). Warming was continued until the moment the patient was extricated (23). The patient was then covered by a self-

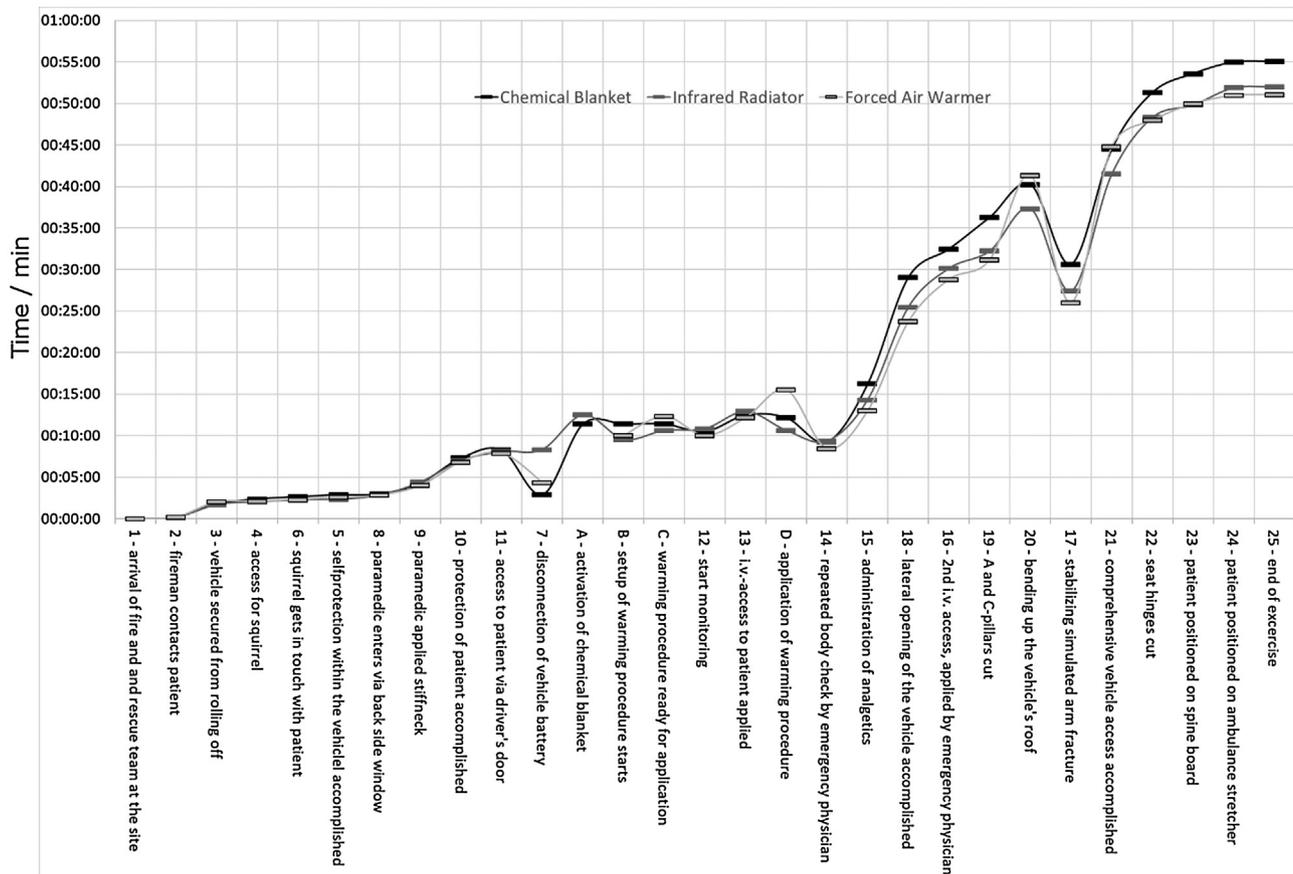


Fig. 4. Significant time points of the extrication scenario of the three different study arms A (chemical blanket), B (infrared radiation), and C (forced-air warming). The graph shows a timely, constant rescue procedure without significant differences between the exercises.

warming chemical blanket (23–25). Since the chemical blanket needs a 30-minute warm-up phase, the chemical blanket was providently unpacked in the same moment (A) when the infrared radiator was installed.

In study arm III (forced-air warmer), the forced-air warming blanket was installed (B) and applied after the front door window was opened, leading the flexible hose through the front door window frame (C). When the patient was extricated, the forced-air warming blanket was replaced by the chemical blanket (23), which had been previously activated (A) so as not to interrupt the overall warming process.

Evaluation: The extrication operations were supervised by six independent observers. They recorded the time course for each event, supervised the screenplay sequence, and documented it photographically and using video.

All participants (fire brigade crew and emergency team) received an evaluation questionnaire to assess the topics as outlined graphed in Fig. 5 by assigning marks (1 = very good to 6 = insufficient), while the volunteer subject was asked to assess the topics according to Table 1.

Results

Incidence analysis

Within the observed three-year period, 292 rescue operations were identified where trapped patients had been primarily reported. In 107 cases, extrication of a trapped patient was performed by the fire brigade and documented accordingly. Extrications that took less than 20 min, have been discarded,

since setup of heating devices would not have been sufficiently fast available. Furthermore, we focussed on rescue operations that took place in the cold seasons (October–April) and identified in total 45 relevant cases (15% of all considered rescue operations), i.e. 15 entrapments a year. This reveals an incidence of about two motor vehicle accidents per month with entrapped patients in the cold season. With regard to the population size of the considered county of about 360.000 inhabitants, this corresponds to an incidence of about 4 entrapments per 100.000 inhabitants every year. The identified cases are depicted in Fig. 6.

The data revealed broad variability in extrication times, up to 80 min. A correlation to accident circumstances, severity, or patient's injury pattern could not be established. Therefore, we were unable to differentiate whether a rapid, so-called crash extrication was performed because of a life-threatening patient status, or whether a gentler, spine-preserving extrication operation was performed if the patient was in a cardiopulmonary stable state.

Integrability study

Weather conditions were generally constant over the day when the outdoor study was performed (Table 2). Significant time points in the extrication process are highlighted in Fig. 4. These events are graphed according to the course of the screenplay, showing a highly routinized extrication procedure without significant variations in the time.

The effective time for each warming procedure (chemical blanket, forced air warmer, IR radiator) was determined and compared (Fig. 7), showing no significant difference in the

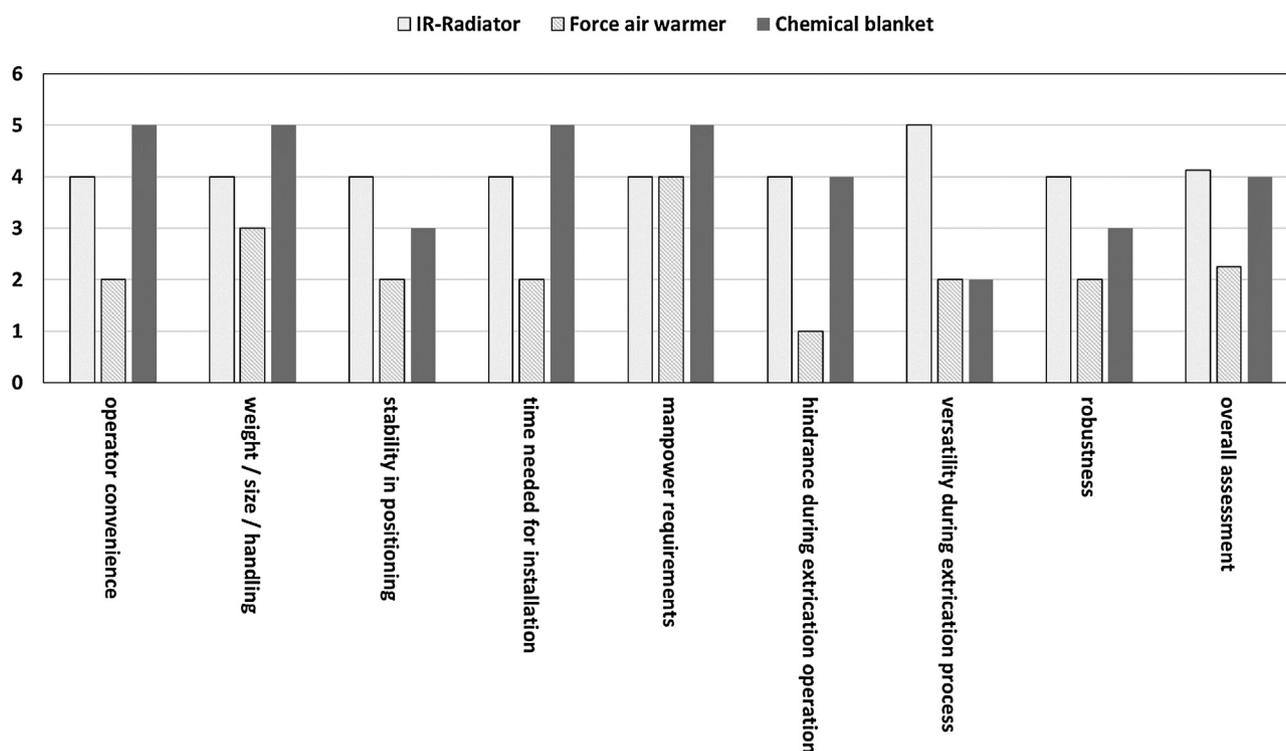


Fig. 5. Topics regarding the warming strategies, as evaluated by the fire brigade crew and emergency team (1 = very good to 6 = insufficient).

application time. Observation of the time course of extrication revealed that the warming techniques did not delay the rescue process. The physiological parameters of the volunteer (skin temperature, heart rate, oxygen saturation) are depicted in Fig. 8a–c and show the greatest increase in surface temperature during infrared radiation.

In total, 20 people who were involved as a firefighter, paramedic, emergency physician or observer completed a questionnaire to give their personal review of the warming techniques with respect to the operator convenience from their assigned fields of function (Fig. 5). The volunteer subject who represented the trapped crash victim in the extrication processes after a vehicle crash scenario was interviewed. His opinion was that all strategies provided a pleasantly cosy warmth, which was most obvious for the infrared-warming and forced-air warmer. The forced-air warmer and the infrared-radiator immediately provided pleasant warmth, while the warming effect of the chemical blanket was significantly delayed. The forced-air warmer and the chemical blanket gave an additional comfortable feeling, described as a kind of physical protection against the extrication side effects (e.g. glass splinters). Though the subject received a helmet and safety goggles, he mentioned the additional protective effect of both blankets. Overall, the forced-air warmer technique was

marginally preferred (Table 1). However, the blanket was seen as a hindrance by the emergency crew regarding access to the patient. They also stated that a further disadvantage of the blanket was the inability to fix it and prevent it from slipping. The fire brigade complained significantly about the hindrance of the forced-air warmer hose, as well as the fact that the blower unit interfered with the extrication procedure. Furthermore, the risk of damaging the fine air mattress was reported, and it was regarded as not being robust enough for application in a sharp-edged cabin. Positioning of the infrared-radiator was documented to be more versatile, and non-hindering. Since the forced air warmer or the infrared warming was interrupted at the time of the extrusion, the warming was continued by the already pre-activated chemical blanket. This method change was rated as unproblematic by the rescue service.

Discussion

Evaluation of the control centre database suggests that in the rural district evaluated, about two vehicle accidents occur every month within the cold seasons. This incidence justifies the inclusion of specialized warming systems in the extrication process, replacing the formerly used and now rejected halogen spotlights. The integrability study revealed from the customer's perspective a preference for the forced-air warming strategy with regard to patient comfort. However, rescue personnel stated that the forced-air warming device represented a significant hindrance in the rescue strategy, supporting a chemical blanket or an infrared radiator, or even a combination of both for maintenance of the patient's temperature during the extrication process.

Car accident scenarios are extremely inhomogeneous with regard to the accident cause and mechanism, velocity of the involved vehicle, car model, number of patients, injury pattern, patient's age, car model, physical environment, meteorological conditions, and time of day, among other factors. Our screenplay represents just one typical scenario, where warming procedures

Table 1

Topics regarding the warming strategies, evaluated by the volunteer subject (1 = very good to 6 = insufficient).

	Infrared radiator	Forced-air warmer	Chemical blanket
Warming effect	2	2	4
Warming distribution	2	1	2
Physical protection	–	++	++
Overall assessment	2	1	3

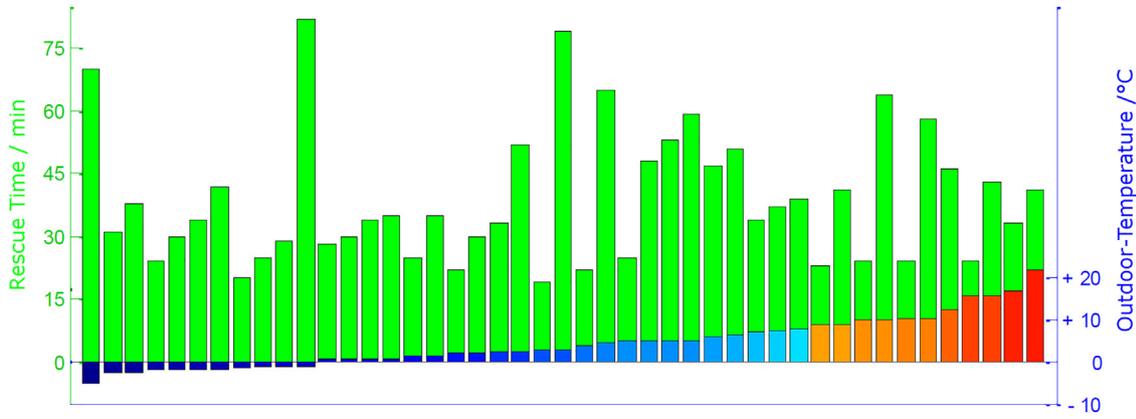


Fig. 6. Car accidents with trapped occupants, as identified in the cold seasons (October– April) within a 3-year period, where extrication took more than 20 min. The graph indicates extrication time and outdoor temperature.

Table 2
Weather conditions during the study.

	Average
Temperature, °C	10
Cloud cover, %	80
Humidity, %	78
Pressure, hPa	1014
Wind speed, ms ⁻¹	3
Precipitation	None

focused on the warming effectiveness, which must be evaluated in subsequent investigations. Although the forced-air warming device is not approved for outdoor applications, this technique represents the gold standard in actively maintaining patient’s heat balance during surgery within hospitals [25]. Therefore, alternative warming techniques have been compared against the forced-air warmer. Although the chemical blanket is not yet accredited for outdoor use, use of these devices is widely carried out in emergency medicine, and has therefore been tested here. Assessment of different warming techniques, however, has also to consider the limited logistic capabilities of the fire engines.

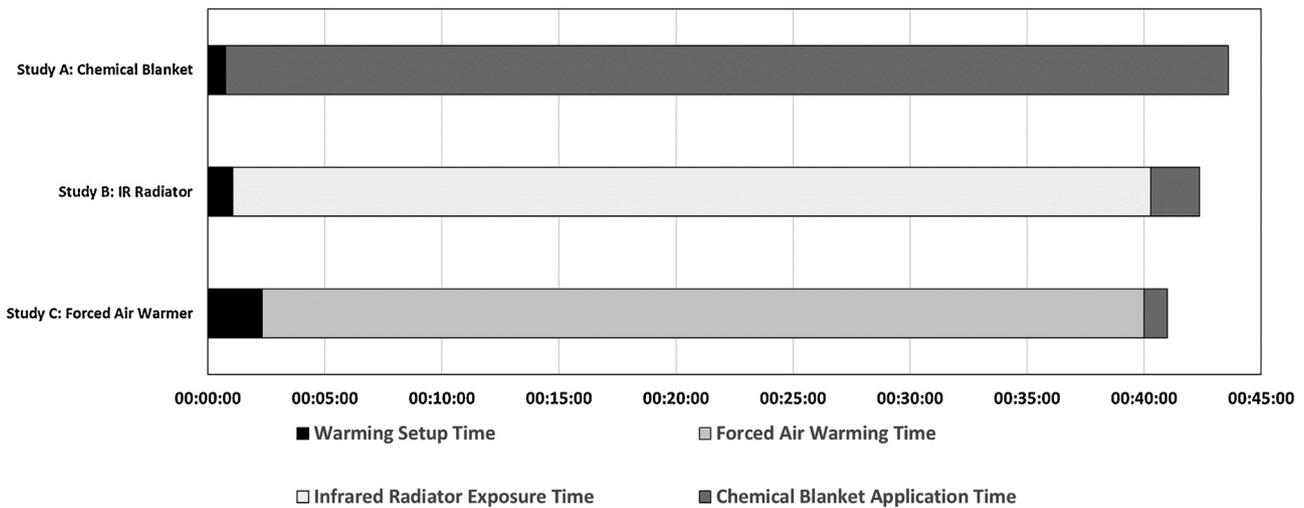


Fig. 7. Comparison of the applied warming strategies, differentiating the setup time that was necessary to install the technique. Infrared radiation and forced-air warming were interrupted at the time point when the patient was extricated. Warming was continued with the chemical blanket, so as not to interrupt the overall warming process.

are indicated. Clearly these warming measures might not be applicable for every rescue operation condition. However, the focus of our study was to evaluate whether warming procedures can be integrated into a typical rescue extrication strategy, without delaying the extrication process itself. We were able to show that none of the warming strategies had an adverse effect on the duration of extrication.

While patient warming using the chemical blanket or the forced air warmer is physically based on thermal conduction, infrared works on thermal radiation. In particular, the infrared-A fraction penetrates deeply into the skin allowing direct warming of the body, which explains the rapid skin temperature increase of the volunteer exposed to the radiator (Fig. 8a). Our study was not

Whereas the low volume chemical blankets can be carried along with any ambulance or fire engines, the packing volumes of the forced-air warmer or infrared-radiator is significant. Therefore, the scope of warming strategy must be considered, assuming a wider range of use for the infrared-radiator, including warming of patients, if a direct contact is not possible, warming of tents in the case of mass casualty incidents, or even warming of the rescue crew during prolonged operations.

Concerning the infrared device, the risk of fire associated with leaking fuels getting into contact with the hot infrared bulb has to be discussed. However, fuel concentration at the stand height of the radiator will be negligible. Furthermore – according rescue instructions [24] – a two-person fireguard is permanently on

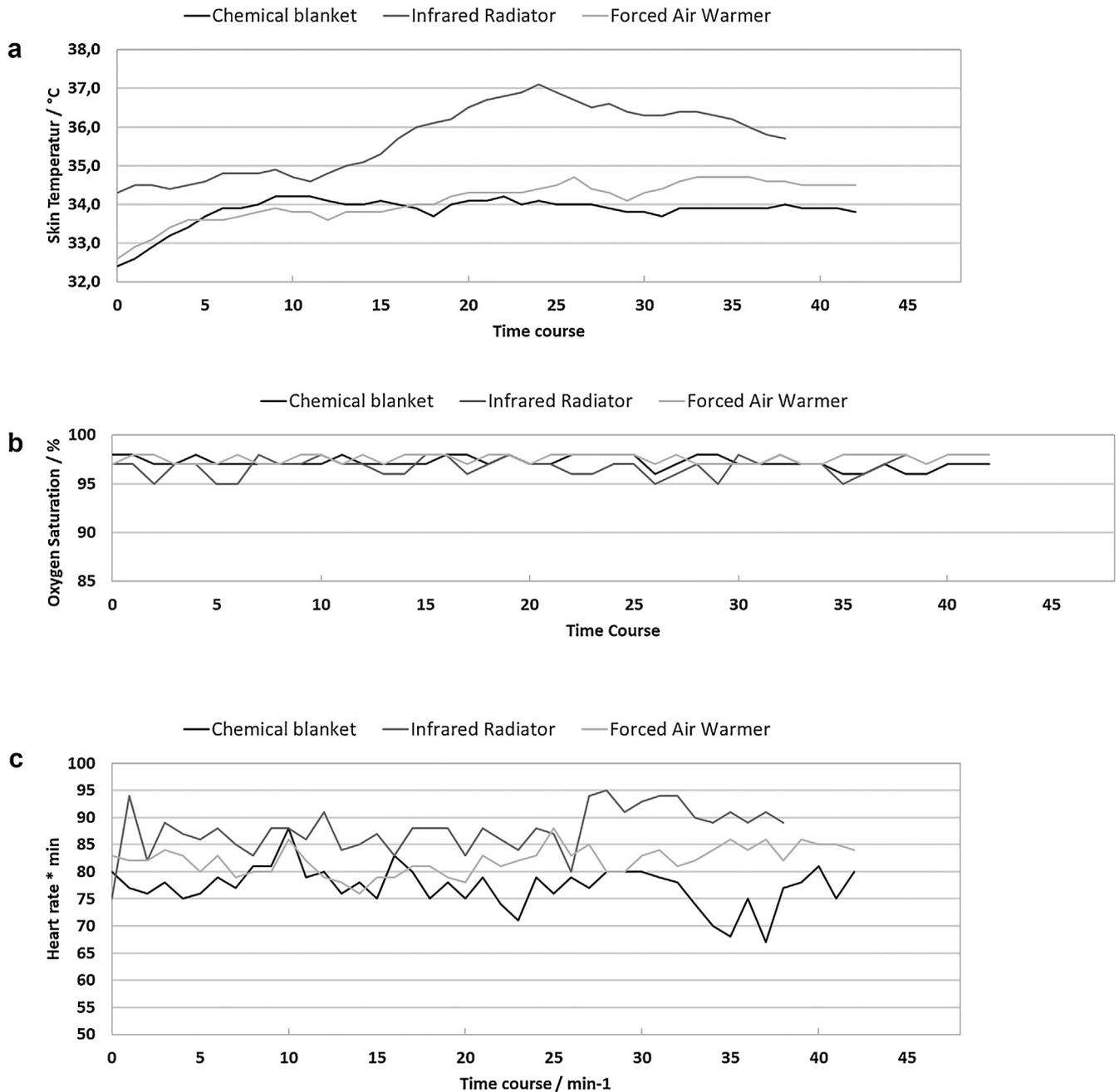


Fig. 8. Time course during the extrication process of (a) surface skin temperature, showing a temperature increase during infrared radiation; (b) heart rate; (c) oxygen saturation, revealing a widely constant behaviour.

stand-by and guarantees immediate intervention. The effectiveness of infrared radiation depends on the distance to the patient, since light intensity decreases as the square of the distance. Therefore, it might necessary in the case of long limousines to place the radiator on the vehicle bonnet or apply infrared radiation from the side (Fig. 2). Infrared radiation will be significantly shielded and absorbed by the windshield; the car windows will be broken anyway to obtain access to the trapped patient, even though this will increase their exposure to the cold. In addition, we assume that car drivers often wear no winter-proof outdoor clothing, especially for longer journeys due to modern car air conditioning or vehicle heating. Furthermore, the patient's clothing sometimes has to be opened for rescue treatment. Thus, patient warming is both

advisable and effective, and was – as shown in the study – perceived by the subject as pleasant. In further design developments, the infrared radiator will be equipped with two separately switchable infrared halogen bulbs, that can be dimmed by a power electronic circuit. An integrated acceleration sensor will be introduced to detect significant position changes for switching off a toppling infrared radiator (automatic cut out), and an LED will be integrated to the signal applying voltage.

Regarding the overall strategy for prevention of trauma-induced, accidental hypothermia, the most important issue is to reduce exposure to the cold by minimizing extrication time, which is impeded by newer vehicle technologies and sheeting of hardened steels. Therefore, rescue cards are supplied that provide

useful information to optimize the time course of vehicle extrication. These cards can be found in the cars or in digital databases on the rescue service's tablet computer [26].

Furthermore, reduction of the general prehospital time, preventing the patient from iatrogenic cooling down during the body check and further treatment, is challenging and should be optimized by duvets, cotton blankets, plastic "bubble-wrap" or low-weight, heat-reflecting space blankets, which are the most common insulation materials for passive warming. These materials, beyond chemical heat pads as an active warming element, are widely available in ambulances, as shown for example in Scandinavian surveys [27,28]. Further active warming devices, such as a forced-air warmer or electrical heating blankets, were found in fixed wing or helicopter emergency medical services [27,28]. An established warming technique used by Scandinavian municipal rescue services for accidents in the cold seasons is the use of a warmed tent, which covers the accident scene; however, this has greater logistic packing volume. An additional strategy that is routinely applied is the administration of warmed infusion; however, this is limited by the volume load. Simple measures to prevent ambulances from cooling down are to close the doors or heat the cabin, which will support warmth homeostasis.

It should be noted that most of the literature discussing hypothermia concerns the perioperative context of intrahospital anaesthesia – concepts which are only to some extent transferable to prehospital emergency [29–32]. Further studies are required to evaluate the hypothermia that occurs during the extrication process after a vehicle accident.

Though our integrability questionnaire is essentially based on the subjective opinion of the rescue team, our results can be summarized to recommend a current workflow for maintenance of patient's temperature balance. Extrication time must be minimized, however taking into account the medical demands, such as spine preserving rescue strategy. The patient should be undressed as little as is necessary for medical examination. If patient is conscious, and in a cardiopulmonary-stable state, and if extrication is expected to be challenging and time consuming, active warming strategies should be considered to prevent sustained hypothermia. Our data suggest that setting up an infrared radiator to expose the patient to the infrared-radiation field can be an efficient and non-hindering strategy. In parallel, a chemical blanket should be activated as early as possible, to bring it to an efficient warming temperature. If extrication is successful, and patient is removed from the infrared-radiation field, the patient should be continuously covered with the pre-activated chemical blanket until hospital delivery.

A key factor in reducing the extrication time, and thus avoiding hypothermia, is the well-coordinated collaboration of a multidisciplinary rescue team. Evaluated and optimized extrusion strategies are just as essential as the use of modern and technologically advanced rescue equipment. A well-defined role concept, which assigns each rescuer his specific task, is therefore indispensable [24].

However, it must be emphasised that the effectiveness of all strategies to maintain of a patient's temperature have to be proven, at least in terms of improved patient outcomes [16,33].

Conclusions

Due to increased vehicle technologies and greater cabin stability, extrication time is significant longer for newer cars, increasing the risk that the trapped occupants may develop sustained hypothermia. Concepts of temperature maintenance, such as the application of an infrared radiator and subsequent use of a warming blanket, should be considered.

However, the minimization of the rescue time through the multidisciplinary cooperation of an intensively trained rescue team remains the most important and effective parameter for avoiding – or at least minimizing the extent – of hypothermia.

Declarations

The author Stroop developed an IR radiator and obtained a utility model protection, which has been transferred to a manufacturer. The further authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

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