Aus der Berufsgenossenschaftlichen Unfallklinik
Klinik für Unfall- und Wiederherstellungschirurgie
an der Universität Tübingen

Validierung der Trainingseffektivität und Einfluss auf subjektive Sicherheit, Versorgungsstrategien und Kommunikation in der prähospitalen Schwerverletzten-Versorgung.

Eine prospektive longitudinale mixed-methods Studie

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1 Einleitung und wissenschaftliche Fragestellung

1.1 Epidemiologie und Versorgungsstandards in der Traumatologie

Jeden Tag werden in Deutschland neun Menschen im Rahmen von Verkehrsunfällen getötet und 1.077 weitere werden verletzt (Deutscher Verkehrssicherheitsrat e.V. 2017). Zwar befindet sich die Zahl der Verkehrstoten auf einem historischen Tiefstand, jedoch haben die polizeilich erfassten Unfälle von 2015 auf 2016 um 2,7% auf 2,58 Mio. Verkehrsunfälle zugenommen (Abbildung 1).

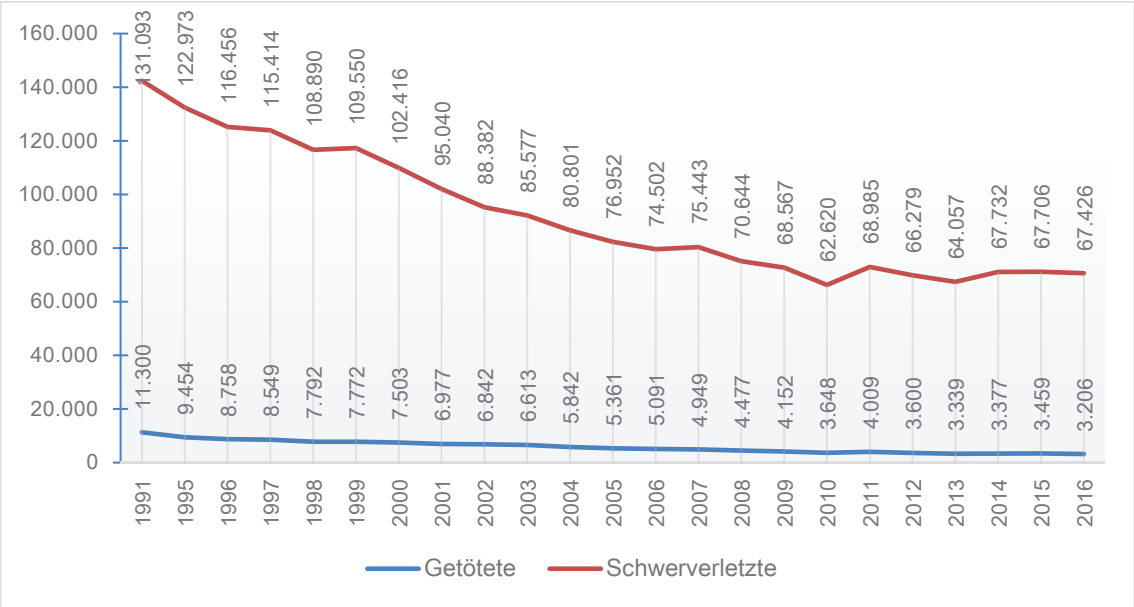

Abbildung 1: Das Straßenverkehrsunfallgeschehen im Überblick, von 1991 bis 2016, entsprechend dem Statistischen Bundesamt (Statistisches Bundesamt (Destatis) 2017b). Insgesamt wurden in 2016 396.666 Verkehrsteilnehmer verletzt, davon entsprechend der polizeilichen Statistik 67.426 schwer.

Obwohl es in Deutschland keine einheitliche Erhebung von Unfällen gibt, schätzt die Bundesanstalt für Arbeitsschutz und Arbeitsmedizin 24.578 Unfalltote und 9,73 Mio. Unfallverletzte in 2015 (Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA) 2017).

Bei durch Verkehrsunfälle Verletzten ist die Gruppe der 18- bis 25-Jährigen – bezogen auf ihren Anteil an der Bevölkerung – überrepräsentiert (Statistisches Bundesamt (Destatis) 2017a). Das Traumaregister der Deutschen Gesellschaft

für Unfallchirurgie weist zum Vergleich in seinem Jahresbericht 2016 ein durchschnittliches Patientenalter von 52 Jahren aus (Deutsches Ärzteblatt 2017).

Zum Patientenkollektiv der Unfallverletzten gehören somit überdurchschnittlich viele junge Patienten. Diese sind meist gesund und im erwerbsfähigen Alter. Die Unfälle haben somit nicht nur erhebliche körperliche und soziale Konsequenzen (Debus et al. 2015; Statistisches Bundesamt (Destatis) 2017a). Neben dem persönlichen Leid und Ausfall an Humankapital sind auch die gesamtwirtschaftlichen Kosten mit Auswirkungen auf das Bruttosozialprodukt von Bedeutung (Jokl 1976). In Deutschland entstehen alleine durch Personenschäden im Rahmen von Verkehrsunfällen volkswirtschaftliche Kosten in Höhe von über 14 Milliarden Euro jährlich (Bundesanstalt für Straßenwesen 2010).

Der Bedeutung der Versorgung dieser Patienten wurde in den letzten Jahren durch verschiedene Maßnahmen Rechnung getragen. Das Weißbuch der Deutschen Gesellschaft für Unfallchirurgie definiert die Standards in der Verletztenversorgung (Siebert 2006). 2008 wurden die Initiative „TraumaNetzwerk DGU®“ gegründet und Traumanetzwerke geschaffen (Ruchholtz et al. 2007), 1993 wurde das Traumaregister etabliert und 2001 wurde erstmals eine S1-Leitlinie zur Behandlung schwerverletzter Patienten, als Vorläufer der heutigen S3-Polytrauma-Leitlinie veröffentlicht (Ruchholtz 2000; Leitlinien-Kommission der Deutschen Gesellschaft für Unfallchirurgie e.V. 2001; Deutsche Gesellschaft für Unfallchirurgie 2016). Die standardisierte Versorgung von Trauma-Patienten im Schockraum hat bereits in den 1970er Jahren mit der Entwicklung des „Advanced Trauma Life Support“ (ATLS) eine neue Richtung erhalten. Seither haben weltweit über 2 Millionen Teilnehmer diesen Kurs absolviert. (Münzberg et al. 2013; Waydhas 2003). Damit hat sich das ATLS-Programm sehr gut etabliert und ist zwischenzeitlich der Standard für Schockraum-Teams, als auch zur Bedingung für die Zertifizierung als Traumazentrum geworden (Deutsche Gesellschaft für Unfallchirurgie 2012). ATLS wird hierzulande, zumindest auf Basis des „kleinsten gemeinsamen Nenners“, als Konzept für den Schockraum gesehen (Helm et al. 2007).

Ruchholtz et al. zeigten in den 1990er Jahren, dass leitlinienbasiertes Arbeiten die Versorgung von Patienten im Schockraum verbessern kann (Ruchholtz et al. 1997). Letztlich ist jedoch ein Nachweis über den Einfluss auf das Outcome von Patienten von Interesse (Waydhas 2003).

Gerade an der Schnittstelle vom Rettungsdienst zum Schockraum profitieren schwerverletzte Patienten von einheitlichen Versorgungsstandards, welche auf medizinisch-wissenschaftlichen Erkenntnissen basieren. Durch eine „gemeinsame Sprache“ werden Entscheidungen einfacher übermittelt, Fehler vermieden und die prioritätenorientierte Patientenversorgung verbessert (Wölfl et al. 2009).

In Anlehnung an die Struktur der Schockraum-Versorgung mit ATLS hat sich eine prähospitale Variante entwickelt. Obwohl es derzeit diverse Trainingskonzepte zur Verbesserung der Schwerverletzten-Versorgung gibt (Münzberg et al. 2014), ist das zugehörige prähospitale Konzept zu ATLS das Prehospital Trauma Life Support (PHTLS®) Konzept.

1.2 Prehospital Trauma Life Support-Kurse

Der zweitägige Kurs schult Rettungsfachpersonal wie Rettungsassistenten und Notfallsanitäter sowie Notärzte in der prähospitalen Versorgung schwerverletzter Patienten (NAEMT 2012). Aktuell werden PHTLS-Kurse in 64 Ländern angeboten, womit dieses Konzept durchaus einen internationalen Standard in der prähospitalen Schwerverletzten-Versorgung darstellt (NAEMT 2017).

Ziel der PHTLS-Kurse ist es, durch Verbesserung des Fachwissens, technischer Fertigkeiten und Sicherheit in klinischem Urteilsvermögen, die Sicherheit in den Verfahren und Abläufen zu erhöhen, damit die Teilnehmer im Berufsalltag schneller und zielgerichteter agieren können. Es werden unterschiedliche Unterrichtsmethoden wie z. B. Vorträge, Fertigkeits- und Szenariotrainings kombiniert, es gibt viele praktische Sequenzen und mit 1:4 ein enges Verhältnis von Dozenten zu Teilnehmern mit kontinuierlicher Interaktion. Die Kurse werden von zertifizierten PHTLS-Instruktoren – Ärzten, Rettungsassistenten, Notfallsanitätern etc. – durchgeführt. Die prioritätenbasierte ABCDE-Struktur

(Airway, Breathing, Circulation, Disability, Exposure) wird intensiv gelehrt und in szenariobasierten Trainingseinheiten geübt. Zusätzlich werden relevante Fertigkeiten, wie zum Beispiel Atemwegsmanagement, Immobilisation, Blutungskontrolle, geübt.

Damit entsprechen die Inhalte und der Umfang auf der einen Seite, sowie die didaktischen Anforderungen auf der anderen Seite den hohen Ansprüchen, wie sie zwischenzeitlich auch als generelle Empfehlung für Kurse zur präklinischen Traumaversorgung beschrieben sind (Deutsche Interdisziplinäre Vereinigung für Intensiv- und Notfallmedizin (DIVI) e.V. 2010).

Ob und inwieweit das PHTLS-Konzept aber inhaltlich mit den Empfehlungen der deutschen S3-Leitlinie Polytrauma/Schwerverletzten-Behandlung der Deutschen Gesellschaft für Unfallchirurgie übereinstimmt, ist nicht eindeutig geklärt.

1.3 Effekte auf die Patientenversorgung durch PHTLS

PHTLS wurde in den 1980er Jahren etabliert und Ende der 1990er Jahre in ersten Studien evaluiert. Ali et al. zeigten, dass die Einführung von PHTLS in Trinidad and Tobago zu einer Verbesserung der Verfahren und Fertigkeiten führte (Ali et al. 1998b) und darüber hinaus die Mortalität signifikant von 15,7% auf 10,6% senkte (Ali et al. 1997). Arreola-Risa et al. zeigten, dass die Einführung von PHTLS in einer mexikanischen Stadt vielfältig die Prozessqualität beeinflusste und beispielhaft die Immobilisation der Halswirbelsäule von 39% auf 67% erhöhte, die Applikation von Sauerstoff von 64% auf 87% und Infusionstherapien von 26% auf 58%. Die prähospitale Versorgungszeit wurde dabei nicht wesentlich verzögert (5,7 ± 4,4 Minuten versus 5,9 ± 6,8 Minuten), jedoch die Anzahl der auf dem Transport verstorbenen Patienten von 8.2% auf 4.7% gesenkt (Arreola-Risa et al. 2000).

1.4 Übertrag auf das europäische Gesundheitssystem

Die ersten Ergebnisse hinsichtlich des Einflusses von PHTLS wurden somit in Entwicklungsländern gewonnen und können schwerlich auf aktuelle und entwickelte Rettungsdienste moderner Gesundheitssysteme übertragen werden. Eine skandinavische Beobachtungsstudie zeigte, dass PHTLS-Training mit einer

nur geringen Reduktion der Mortalität assoziiert ist. Hier war das Mortalitätsrisiko ohne PHTLS-Training 4,7% (36/763), mit PHTLS-Training 4,5% (94/2067). Die geschätzte absolute Risikoreduktion lag bei 0,5 geretteten Patienten pro 100.000 Einwohner, wenn PHTLS flächendeckend implementiert sei (Johansson et al. 2012). In einer Subgruppenanalyse bei Verkehrsunfällen konnte keine Reduktion der Mortalität beobachtet werden (Blomberg et al. 2013).

Damit erscheint es fraglich, ob "Mortalität" als einziger Endpunkt ausreicht, um die Effekte von PHTLS oder ähnlichen Kursen in der modernen Notfallversorgung zu bewerten.

1.5 Subjektive Sicherheit in der Versorgung schwerverletzter Patienten

Bei tödlichen Verkehrsunfällen sind eine Vielzahl von Menschen neben dem Patienten betroffen. Das Verkehrsministerium rechnet mit durchschnittlich 113 betroffenen Personen wie Freunden, Angehörigen und Bekannten – aber auch Einsatzkräften (Bundesministerium für Verkehr und digitale Infrastruktur 2017). Während sich die Mortalität bei Traumapatienten in Deutschland lange Jahre im Abwärtstrend befand, bedeuten Einsätze mit Schwerverletzten für das eingesetzte Personal nach wie vor Stress in komplexen Situationen mit multidisziplinären Teams – bei gleichzeitig abnehmender Routine aufgrund fallender Fallzahlen (Gebhardt 2006; Gries et al. 2005; Quilici et al. 2005; Valentin et al. 2015). In der prähospitalen Versorgung liegen im Vergleich zur Schockraum-Versorgung meist weniger Angaben zum Einsatzgeschehen und zu Patienten vor. Die Unvorhersehbarkeit der Anzahl der Verletzten, die Heterogenität des Patientengutes und die wechselhaften Umgebungsvariablen wie Wetter, Örtlichkeit der Einsatzstelle etc. gehen mit einer hohen mentalen Belastung einher. Stress kann durch verschiedene Tests wie z.B. durch Herzfrequenz- und Cortisol Messungen im Speichel, sowie durch Workflow-Analysen in der Realität als auch im Simulationstraining nachgewiesen werden (Gebhardt 2006; Valentin et al. 2015). Moorthy et al. zeigten in laparoskopisch-chirurgischen Tests, dass Stress zu mehr fachlichen und wissensbasierten Fehlern führt (Moorthy et al. 2003). Interessanterweise wurde in medizinischen Simulationstrainings mittels Alpha-Amylase-Bestimmung im Speichel gezeigt,

dass Training einen ähnlichen Stress wie echte klinische Situationen verursachte. Zugleich kann jedoch Stress durch adäquates Training reduziert und die Leistung verbessert werden (Müller et al. 2009).

Insofern ist es von großem Interesse, welchen Einfluss die Schulungen und Trainings auf die subjektive Sicherheit in der Versorgung schwerverletzter Patienten haben.

1.6 Evaluierung von Schulungserfolgen

Derzeit gibt es zahlreiche Angebote für Schulungen in der Akut- und Notfallmedizin, wie zum Beispiel mit Fokus auf Traumata, Reanimation, klinisch/präklinische Tätigkeit etc. Die meisten Kurse haben gemeinsam, dass sie gut strukturiert sind, einen hohen Praxisanteil haben und meist mit einer schriftlichen und praktischen Erfolgskontrolle enden. Jedoch sind die Erfolgskontrollen selten und nicht durchgängig validiert (Ringsted et al. 2007). Zur objektiven Beurteilung von Fertigkeiten und Fähigkeiten im Medizinstudium wurde 1975 erstmals ein OSCE (objective structured clinical examination) eingesetzt (Harden et al. 1975). OSCE gelten heute als gut validiert und zuverlässig (Crossley et al. 2002; Hodges et al. 1998; Müller et al. 2016). Anwendung finden OSCE zur Überprüfung von non-technical skills (Passauer-Baierl et al. 2013), technischen Fertigkeiten (Pape-Koehler et al. 2013; Martin et al. 1997), in Trainings oder zur Beurteilung realer Patientenversorgung (Carter et al. 2013). Obwohl bereits in den 1990er Jahren OSCE in der notfallmedizinischen Ausbildung erprobt wurden (Lunenfeld et al. 1991), findet sich dazu vergleichsweise wenig Literatur im Vergleich zu anderen medizinischen Fächern (Ruesseler et al. 2010).

1.7 Lernen und Kompetenzentwicklung

Damit Fortbildungen wirksam sein können, muss jedoch verstanden werden was zur Entwicklung von Wissen und Kompetenz beträgt.

Ein akzeptiertes Modell für die Entwicklung von Expertise wurde von Dreyfus entwickelt und sieht die stufenlose Entwicklung: „Neuling - Fortgeschrittener Anfänger - Kompetenter Anwender - Erfahrene Anwender – Experte“ vor

(Dreyfus und Dreyfus 1986). Immer wieder wurde versucht dieses Modell auf die Entwicklung klinischer Kompetenzen anzuwenden (Carraccio et al. 2008). Während in den ersten Stufen mit wenig oder kaum Berufserfahrung große Entwicklungsschritt möglich sind, ist es auf dem Weg zum Experten immer seltener möglich signifikante Unterschiede zu erzielen. Beispielhaft zeigt eine Untersuchung zur Diagnosesicherheit beim Akuten Koronarsyndrom unterschiedliche Ausprägungen in Diagnostik und Therapie zwischen Kardiologen und Anästhesisten, welche jedoch keinen Einfluss mehr auf die Mortalität der Patienten haben (Breckwoldt et al. 2008).

Mit zunehmender Berufserfahrung verändert sich die Organisation von Wissen, denn meist wird die eigene Erfahrung immer wichtig – häufig auch wichtiger als eine systematische Wissensorganisation (Schmidt und Rikers 2007). So konnte gezeigt werden, dass gerade bei berufserfahrene Ärzten eine signifikant schlechtere Leitlinienkenntnis vorherrscht (Breckwoldt und Gruber 2012).

Da Selbsteinschätzung der eigenen medizinischen Tätigkeit häufig nicht valide ist (Davis et al. 2006), ermöglichen Simulationstrainings mit entsprechend videogestützten Debriefings eine objektive Sicht auf Teams und ermöglichen eine Reflexion des eigenen Handelns (Rall und Gaba 2009b).

Je spezieller die Erfordernisse sind, umso wichtiger wird die entsprechende Schulung. 80% der Teilnehmer von PHTLS-Kursen gaben in einer Befragung an, dass sie nur ungenügend auf prähospitale Notfälle während ihrer Aus- und Weiterbildung vorbereitet wurden (Frank et al. 2015). Dem wurde zum Beispiel an der Medizinischen Fakultät Heidelberg Rechnung getragen, als dass sogenannte TEAM-Kurse von ATLS und PHTLS entwickelt wurden, welche als Wahlfach die traumatologisch-notfallmedizinischen Inhalte bereits im Medizinstudium anbieten (Häske et al. 2015; Wölfl et al. 2012).

Klein et al. konnten zeigen, dass intrinsisch motivierte Teilnehmer von ATLS-Kursen eher bereit sind in ihre Ausbildung zu investieren und umgekehrt. Die externe Finanzierung von Kursen für die Teilnehmer spornt dabei nicht an und verursacht sogar schlechtere Kursergebnisse (Klein et al. 2017).

1.8 Systemänderungen

Um eine tatsächliche Veränderung und Optimierung herbeizuführen, ist jedoch ein systematischer Ansatz notwendig. Trainings von partiellen Bereichen oder Abteilungen, oder auch persönliches Engagement zeugen zwar von hoher intrinsischer Motivation, sind aber bezogen auf eine zu versorgende Population und Verbesserung der Gesundheitssysteme weniger effektiv (Patterson et al. 2013). Der systematische Ansatz ist jedoch meist deutlich aufwendiger, weil er auch Personal inkludiert, welches deutlich weniger engagiert ist.

Eine Kombination aus systematischem Ansatz und intrinsischer Motivation sind auch der Schlüssel zum Erfolg für sogenannte Hochleistungsteams. Diese haben alle gemeinsam, dass sie mit hoher Eigenmotivation ein gemeinsames Ziel verfolgen (Mitarbeiter) und dabei durch einen systematischen Ansatz (Arbeitgeber) unterstützt und gelenkt werden (Pawlowsky und Mistele 2008). Solche Systeme, kombiniert mit entsprechender Qualitätssicherung werden als sehr effektiv hinsichtlich Patientensicherheit und Systementwicklung gewertet (Dunford et al. 2009; Hughes 2008).

Unter der Überschrift „Die Formel für das Überleben in der Wiederbelebung“ publizierten Søreide et al. die drei wesentlichen Bausteine für eine systematische Steigerung der Qualität: „Medizinische Wissenschaft x edukative Wissenschaft und Effizienz x lokale Umsetzung = Überleben“ (Søreide et al. 2013). Auch für die systematische Verbesserung in der Traumaversorgung wurden drei relevante Aspekte identifiziert: Wissenschaft, Interdisziplinarität und Interprofessionalität und manuelle Fertigkeiten (Wich und Giannoudis 2015). Dabei wird angeführt, dass wissenschaftliche Erkenntnisse in Leitlinien einfließen und diese berücksichtigt werden müssen. Egal ob im prähospitalen Team oder im Schockraum: der verantwortliche Teamleader muss alle beteiligten Disziplinen und Fachgruppen für eine optimale Patientenversorgung koordinieren und motivieren. Die Autoren verweisen aber auch darauf, dass das beste theoretische Wissen alleine ohne Training der Fertigkeiten mit dem notwendigen Equipment nicht ausreicht (Wich und Giannoudis 2015).

1.9 Rationale und Forschungsfrage

Ausgangspunkt dieser Arbeit ist, dass in einem Rettungsdienstbereich ein Qualitätsverlust und eine abnehmende Mitarbeiterzufriedenheit mit Fortbildungen vermutet wird. In einem ersten Schritt wird daher die Mitarbeiterzufriedenheit erhoben und ein neues Fortbildungskonzept entwickelt.

Der Schwerpunkt der Untersuchung beschreibt und analysiert die Effekte von systematischem Teamtraining zur prähospitalen Versorgung von schwerverletzten Patienten. Für unterschiedliche Perspektiven wurde ein prospektiver mixed-methods Ansatz verwendet. Ein großes Teilprojekt war hierbei die Entwicklung einer Checkliste als „Assessment-Tool“, um eine Vergleichbarkeit von Videodaten und somit eine objektive Analyse zu ermöglichen.

2 Ergebnisse

2.1 Problembeschreibung

Häske D, Kreinest M, Wölfl CG, Frank C, Brodermann G, Horter J, Suda AJ, Gliwitzky B, Beckers SK, Stöckle U, Münzberg M (2013) Bericht aus der Praxis: Strukturierte Fortbildung zur Verbesserung der Versorgungsqualität im Rettungsdienst. Einsatz-Supervision als neuer Ansatz im Bereich der Rettungsdienst-Fortbildung in Wiesbaden und im Rheingau-Taunus-Kreis? Zeitschrift für Evidenz, Fortbildung und Qualität im Gesundheitswesen 107: 484–489 (Häske et al. 2013).

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AUS- UND FORTBILDUNG

Bericht aus der Praxis: Strukturierte Fortbildung zur Verbesserung der Versorgungsqualität im Rettungsdienst. Einsatz-Supervision als neuer Ansatz im Bereich der Rettungsdienst-Fortbildung in Wiesbaden und im Rheingau-Taunus-Kreis?

Practice report: Structured training to improve quality of care in emergency medical service. On-scene supervision: A new approach to emergency medical service training in Wiesbaden and Rheingau-Taunus-Kreis?

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SCHLÜSSELWÖRTER
Rettungsdienst;
PHTLS;
AMLS;

Zusammenfassung Die Rettungsdienste in Wiesbaden und im Rheingau-Taunus-Kreis bemühen sich in den letzten Jahren um einheitliche Strukturen. In jährlichen Prüfungen der Rettungsassistenten sind nur in wenigen Fällen etablierte Schemata zu finden, so dass vermutet werden muss, dass die Behandlungsabläufe beim Patienten ebenfalls nicht strukturiert sind. Material

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Supervision;
Fortbildung

und Geräte werden nicht einheitlich gehandhabt und die Zufriedenheit der Mitarbeiter hat in den letzten Jahren deutlich abgenommen.

Als Lösungsansatz werden alle Rettungsassistenten in einheitlichen und strukturierten Fortbildungen geschult. Dabei kommen die international anerkannten Konzepte „PHTLS“ (Pre Hospital Trauma Life Support) und „AMLS“ (Advanced Medial Life Support) zur Anwendung. Zusätzlich sollen in Übungseinheiten Fertigkeiten und der Umgang mit Geräten geübt, sowie eine Einsatzsupervision etabliert werden.

KEYWORDS
Emergency medical service;
PHTLS;
AMLS;
supervision;
training

Summary In recent years, the emergency medical services in Wiesbaden and the Rheingau-Taunus district made great efforts to standardise structures. Since there are only few established procedures in the annual examinations for paramedics, there is reason to assume that treatment procedures for patients have not been standardised either. Materials and equipment are not handled uniformly, and employee satisfaction has significantly decreased over the last few years.

To solve these problems, all paramedics undergo standardised and structured trainings. These training courses make use of the internationally accepted PHTLS (Pre-Hospital Trauma Life Support) and AMLS (Advanced Life Support Medial) programmes. In addition, practising skills and handling the equipment as well as on-scene supervision is to be established in practical training sessions.

Die zuständigen Rettungsdienstträger in Wiesbaden und im Rheingau-Taunus Kreis haben in den letzten Jahren durch ein strukturiertes Aus- und Fortbildungskonzept viel für eine einheitliche Struktur, Standardisierung und Vereinheitlichung im Rettungsdienst gesorgt. Trotzdem orientieren sich die bisherigen Behandlungsabläufe beim Patienten allerdings nur in wenigen Fällen an den vorgegebenen Schemata und Algorithmen.

Um die aufgeführten Defizite in den Strukturen und Standards, einheitlichen Geräte-Anwendungen und Prozessen, sowie den Fortbildungsevaluationen zu verbessern, soll das gesamte Rettungsfachpersonal der Rettungsdienste Wiesbaden und Rheingau-Taunus-Kreis an strukturierten internationalen zertifizierten Fortbildungsprogrammen teilnehmen.

Hintergrund

Im Rettungsdienstbereich Wiesbaden sind fünf Leistungserbringer (vier Hilfsorganisationen, ein privater Anbieter) vom Rettungsdienstträger mit der Leistungserbringung im Rettungsdienst beauftragt. Wiesbaden und der Rheingau-Taunus-Kreis umfassen zusammen 462.098 Einwohner welche von 375 Einsatzkräften zuzüglich der Notärzte versorgt werden.

Trotz der in den letzten Jahren durchgeführten Vereinheitlichung, Strukturierung und Standardisierung der Jahresfortbildung des Rettungsfachpersonals in Wiesbaden und im Rheingau-Taunus-Kreis besteht seitens des Rettungsdienstträgers der Eindruck, dass die Umsetzung der vermittelten Inhalte in der Praxis, insbesondere hinsichtlich der Standardisierung, unzureichend ist.

Standardisiertes Vorgehen

Im jährlichen Zyklus wird bisher das Personal im Rettungsdienst Wiesbaden und Rheingau-Taunus-Kreis in den Erweiterten Versorgungsmaßnahmen (EVM) geschult und geprüft (Grundlage hierfür ist die „Verordnung zur Durchführung des Hessischen Rettungsdienstgesetzes vom 3. Januar 2011“). Der sogenannte Begriff der „erweiterten Versorgungsmaßnahmen“ wird nicht einheitlich verwendet und hat keine konkrete Definition. In aller Regel — und so auch in Wiesbaden und dem Rheingau-Taunus-Kreis - werden jedoch unter (erweiterten) Versorgungsmaßnahmen Anwendungen verstanden, welche durch Rettungsassistenten ausgeführt werden. Diese beinhalten bestimmte Fertigkeiten (z.B. Atemwegssicherung) oder pharmakologische Therapien, welche durch Algorithmen geregelt sind und in welchen jeder Rettungsassistent explizit durch den Ärztlichen Leiter Rettungsdienst auf die Handlungskompetenz hin geprüft (zertifiziert) wird. Basis zur Ausgestaltung sind meist Empfehlungen der Bundesärztekammer [1], oftmals werden jedoch EVM als „Regelkompetenz“ ausgeführt und sind auch im Umfang ganz unterschiedlich [2,3]. Die Prüfung erfolgt schriftlich, mündlich und praktisch, der Fokus liegt im Rahmen der praktischen Überprüfung anhand von Fallbeispielen auf der korrekten Durchführung der Fertigkeiten und algorithmusbasierten Pharmakotherapien. Ausschlusskriterien welche zum nicht Bestehen der Prüfung führen, sind definiert.

Im Rahmen der EVM wird seit 2011 auch das ABCDE-Schema (Airway, Breathing, Circulation, Disablitiy, Exposure) als initiale Herangehensweise an den Notfallpatienten vorgegeben und unterrichtet (Abb. 1). Im Rahmen der jährlichen EVM-Prüfungen, welche durch die Ärztlichen Leiter Rettungsdienst Wiesbaden und Rheingau-Taunus durchgeführt werden, zeigt sich, dass die Prüfungsfallbeispiele zwar im Sinne der Erweiterten Versorgungsmaßnahmen abgearbeitet werden, jedoch ist nach Einschätzung der ÄLRD eine reproduzierbare Grundstruktur der Notfallbehandlung im Sinne des ABCDE-Schemas in weniger als 5% der Fälle zu erkennen. Dadurch entsteht die Annahme, dass auch die Umsetzung in der Praxis nicht stattfindet. Vielmehr wird die Einteilung des Patientenzustandes in „kritisch/nicht kritisch“ größtenteils ohne strukturierte Entscheidungshilfe und damit nicht aufgrund der vorgefundenen Befunde

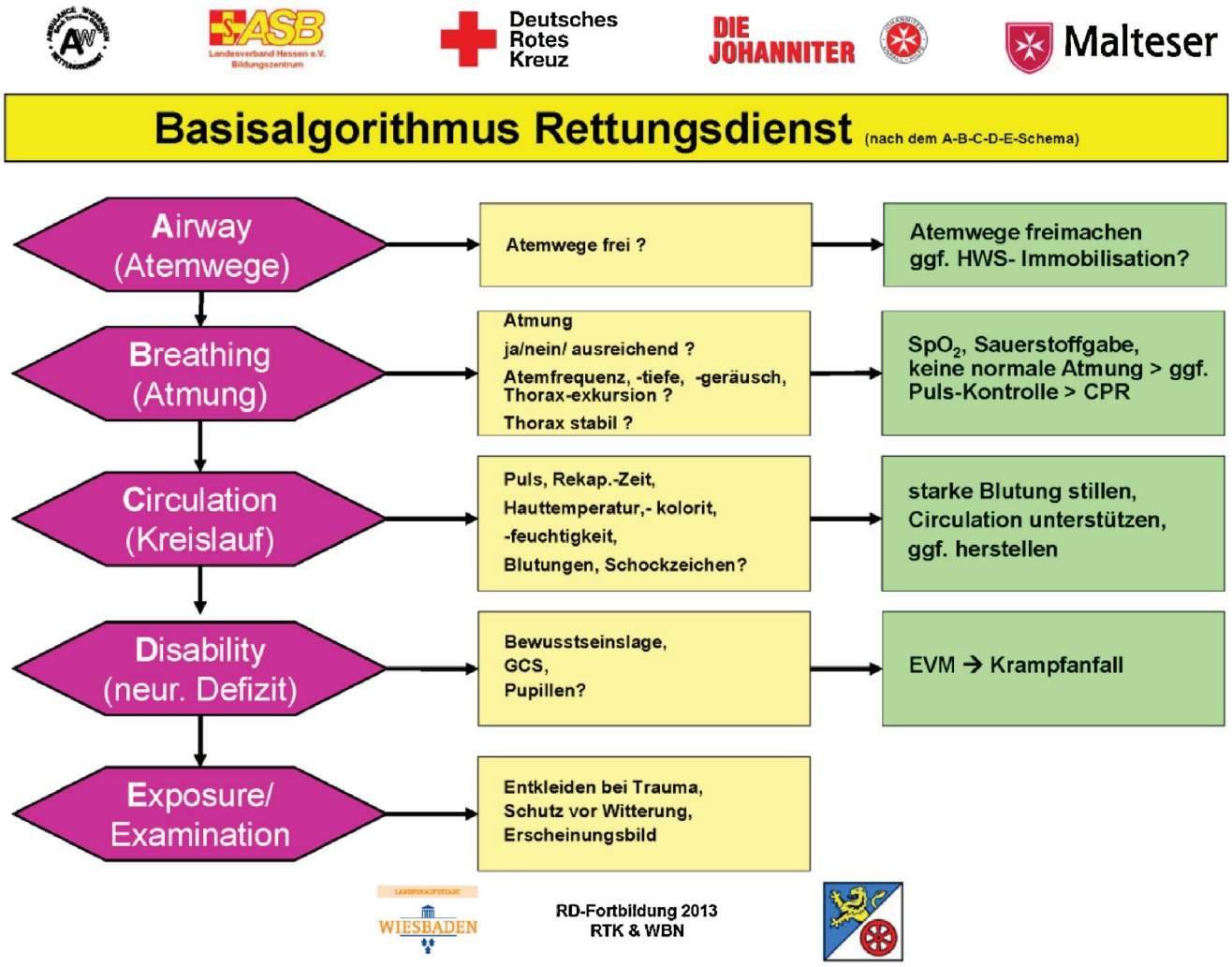

Abbildung 1 Algorithmus Initiale Herangehensweise Rettungsdienst Wiesbaden.

getroffen. Auch der Einsatz von Material und Ausrüstung ist derzeit im entsprechenden Rettungsdienstbereich nicht einheitlich.

Das Beherrschen von Fertigkeiten und der Umgang mit Geräten

Die erforderliche Übung, um die im Rettungsdienst notwendigen Fertigkeiten zu beherrschen, wird seitens des Rettungsfachpersonals in den Jahresfortbildungen nur marginal anerkannt und akzeptiert. Auch der sichere Umgang mit Geräten leidet darunter. Dies mag oftmals dem Verhältnis von zu vielen Übenden auf die Anzahl der Instruktoren geschuldet sein, dadurch ist die Übungsmöglichkeit für den Einzelnen oft viel zu gering.

Supervision in der täglichen Praxis

Von den Notärzten wird erwartet, dass sie regelmäßige Einsatz-Debriefings mit den beteiligten Teams durchführen. Eine Vorgabe für die Struktur und die Inhalte des Debriefings gibt es nicht und tatsächlich finden die Debriefings nicht in der Regelmäßigkeit statt, wie dies vom Rettungsdienstträger gewünscht wird. Auch um die Umsetzung des ABCDE-Schemas am Patienten im Einsatz zu beurteilen, müsste eine Einsatz-Supervision stattfinden. Jedoch gibt es derzeit im deutschen Rettungsdienst kein bekanntes Konzept zur strukturierten Rückkopplung der eigenen Arbeit in der täglichen Praxis an das Einsatzpersonal. Eine systematische Aufarbeitung und Rückmeldung über die tägliche, praktische Arbeit des Rettungsfachpersonals liegt dem für Wiesbaden und den Rheingau-Taunus-Kreis verantwortlichen Rettungsdienstträger also nicht vor.

Praktische Umsetzung, Mitarbeiterzufriedenheit

Die operative Durchführung der Jahresfortbildung obliegt den Leistungserbringern. Fortbildungen werden gemäß den aktuellen pädagogischen Erkenntnissen durchgeführt. Der Fortbildungsschwerpunkt 2012 in Wiesbaden und im Rheingau-Taunus-Kreis nannte sich „Lernen lernen“ und fokussierte das Lernen im Lernfeld. Folgende Aspekte

Tabelle 1 Mitarbeiter-Befragung durch den Ärztlichen Leiter Rettungsdienst, Auswertung durch die Projektgruppe. Die statistische Berechnung erfolgte mittels χ^2-Test.

Jahr	n gesamt	Median	Signifikanz	Sehr gut	Gut	Befriedigend	ausreichend	mangelhaft	Keine Angabe
Wie bewerten Sie die Fortbildung?									
2011	401	2,10	p = 0,0004	19% (n=78)	57% (n=229)	18% (n=73)	5% (n=19)	0% (n=2)	0% (n=0)
2012	408	2,36		12% (n=50)	52% (n=214)	24% (n=98)	7% (n=29)	3% (n=13)	1% (n=4)
Wie beurteilen Sie die Fortbildung hinsichtlich der Vermittlung theoretischen Wissens?									
2011	401	2,04	p = 0,08	20% (n=80)	60% (n=242)	16% (n=63)	3% (n=14)	0% (n=2)	0% (n=0)
2012	409	2,18		18% (n=75)	54% (n=222)	19% (n=77)	6% (n=23)	2% (n=8)	1% (n=4)
Wie bewerten Sie die Praxisnähe / berufliche Relevanz?									
2011	401	2,09	p < 0,0001	21% (n=86)	53% (n=212)	21% (n=85)	3% (n=13)	1% (n=3)	0% (n=2)
2012	409	2,31		19% (n=76)	46% (n=187)	25% (n=102)	7% (n=29)	3% (n=14)	0% (n=1)
Gelang es den Dozenten, die Themen verständlich zu vermitteln?									
2011	400	1,74	p = 0,32	34% (n=135)	59% (n=235)	7% (n=28)	0% (n=1)	0% (n=0)	0% (n=1)
2012	409	1,69		39% (n=160)	52% (n=214)	7% (n=30)	0% (n=2)	0% (n=0)	1% (n=3)

erschienen bei der Einführung „Lernen im Lernfeld“ dem Rettungsdienstträger interessant: Durch die gemeinsame Erarbeitung von Fachthemen in Kleingruppen sind alle Beteiligten aufgefordert, sich aktiv einzubringen. Der integrative Lernansatz verbindet alle Facetten und Komponenten, wie zum Beispiel Einsatztaktik, Anatomie, Physiologie, Pathophysiologie und Teamarbeit.

Seit 2009 führt der Rettungsdienstträger flächendeckend eine Evaluation aller durchgeführten Fortbildungen im Rettungsdienstbereich durch. Die Evaluation ist standardisiert und wird jährlich ergänzt, um spezifische Fragen zu den Hauptfortbildungsthemen zu evaluieren. Für das vorliegende Projekt wurden die Evaluationen ausgewertet und zeigten eine signifikante Verschlechterung in der Bewertung der Fortbildungen und der Zufriedenheit der Mitarbeiter [Tab. 1].

In der Summe zeigen sich damit vier Problemfelder: aktuelle didaktische Methoden in dem obengenannten Fortbildungskonzept konnten die Strukturen und Standards im Einsatz noch nicht etablieren. Des Weiteren ist der Umgang mit Materialien und Geräten nicht einheitlich. Außerdem konnte eine Beurteilung der rettungsdienstlichen Prozesse sowie eine Supervision nicht erfolgreich umgesetzt werden. Zuletzt sind die Evaluationen der Fortbildungen und die Zufriedenheit der Mitarbeiter im Vergleich zum Vorjahr schlechter ausgefallen.

Methodik

Um die Defizite aufzuarbeiten, werden folgende Schwerpunkte angegangen:

Einheitliche strukturierte Fortbildung für alle Rettungsassistenten

Ziel ist eine Standardisierung des Vorgehens bei der Behandlung von Notfallpatienten gemäß des ABCDE-Schemas, einer schnellen Identifikation von kritisch erkrankten Patienten, sowie einer verbesserten klaren Kommunikation innerhalb des Rettungsteams [4].

Als zielführend wurde eine strukturierte und gut bewertete Fortbildung gesucht. Dazu wurde das Trainingsprogramm PHTLS (Pre Hospital Trauma Life Support) ausgewählt.

Zusätzlich ist im Jahr 2014 geplant, das Format AMLS (Advanced Medical Life Support) als zertifiziertes Format für internistische Notfälle zu etablieren. AMLS ist ein internationales Konzept zur akutmedizinischen Versorgung von internistischen Patienten. Auch hier steht in Deutschland für drei Teilnehmer je ein Instruktor zur Verfügung.

Zum Abschluss sollen 2015 jährlich spezielle wiederholende Fertigkeitstrainings eingeführt werden. Eine Rezertifizierung von PHTLS und AMLS ist alle vier Jahre gefordert um den aktuellen Entwicklungen in der Notfallmedizin Rechnung zu tragen. Gerade die regelmäßigen Zertifizierungen können dazu beitragen, langfristig die Qualität durch einheitliche Standards zu sichern.

Übungseinheiten für alle Rettungsdienstmitarbeiter

Jeder Mitarbeiter muss zwei Mal pro Jahr eine Übungseinheit in der Arbeitszeit absolvieren, in welcher der richtige Umgang mit den eingesetzten Geräten und Hilfsmitteln unter Anleitung vertieft werden soll.

Thematisch orientieren sich die Übungseinheiten für 2013 an den Fertigkeitstrainings der bevorstehenden PHTLS-Kursen und werden 2014 um die Inhalte der AMLS-Kurse ergänzt. Die Übungseinheiten dienen dem Erhalt der Fertigkeiten, können jedoch nicht die regulären Kurse ersetzen, da diese die Fertigkeiten in die Prozesse der Patientenversorgung integrieren. Im Wesentlichen handelt es sich dabei um Lagerungsarten und korrekte Fixierung auf dem Spineboard, sowie die richtige Verwendung von Schienungsmaterial wie Extremitätenschienen und Vakuummatratze. Ergänzt werden die Fertigkeiten um die korrekte Helmabnahme, das Anlegen einer Halskrause und die Durchführung der Inline-Stabilisation, sowie die Verwendung des intraossären Bohrers, die Vorbereitung/Assistenz bei der Koniotomie

und Thoraxdrainage, sowie die Anlage des Beckengurtes und Rettung aus dem Fahrzeug.

Die Übungseinheiten sollen auf allen Rettungswachen einheitlich umgesetzt werden.

2012 wurden bereits alle Lehrrettungsassistenten und Praxisanleiter für die kommenden Übungseinheiten geschult. Um eine einheitliche Durchführung der verschiedenen Übungen zu gewährleisten, wird den Mitarbeitern im Voraus ein unterstützendes Praxisskript zur Verfügung gestellt. Das Skript enthält u.a. eine exakte Festlegung des Übungsmaterials in Form einer Checkliste. Die Praxisanleiter und Lehrrettungsassistenten sind für die Wartung und Überprüfung des Übungsmaterials im täglichen Routinebetrieb verantwortlich.

Eine entsprechende Schulung nach einheitlichem Standard findet für alle Praxisanleiter und LRA statt.

Die Durchführung der Übungseinheiten wird durch die Lehrrettungsassistenten und Praxisanleiter dokumentiert und evaluiert.

Einsatz-Supervision

Um den Mitarbeitern ein Feedback zu ihrer täglichen Arbeit geben zu können, soll eine Supervision im Einsatz etabliert werden. Dadurch werden eine Beurteilung und eine systematische Rückmeldung zur praktischen Arbeit in der täglichen Routine nach festgelegten Kriterien ermöglicht. Die genauen Inhalte und Kriterien zur Beurteilung der Mitarbeiter werden in einer gemeinsamen „Projektgruppe Supervision 2013“ von Rettungsdienstträger und Leistungserbringern erarbeitet.

Ziel ist es jeden Mitarbeiter mindestens einmal pro Jahr in realen Bedingungen zu supervidieren und ein strukturiertes Feedback zu geben.

Diskussion

Die Fortbildungsthemen werden seit sechs Jahren unter Moderation des Rettungsdienstträgers festgelegt. Hinsichtlich der Fortbildung besteht eine enge Kooperation mit dem benachbarten Rheingau-Taunus-Kreis. Die Jahresfortbildungen werden gemeinsam bereichsübergreifend durchgeführt. Ein flächendeckendes Frühdefibrillationsprogramm wurde bereits 2001 implementiert. Seit 2005 sind alle Rettungsassistentinnen und Rettungsassistenten, im entsprechenden Rettungsdienstbereich, in EVM (erweiterte Versorgungsmaßnahmen) geschult und zertifiziert.

Die Jahresfortbildung wird von den Lehrrettungsassistenten (LRA) der Leistungserbringer durchgeführt. Erarbeitet wurden die festgelegten Fortbildungsthemen in den vergangenen Jahren von den Lehrrettungsassistenten in Abstimmung mit dem Ärztlichen Leiter Rettungsdienst (ÄLRD). Seit 2007 gibt es ein gemeinsames Fortbildungsskript im Rettungsdienstbereich Wiesbaden und Rheingau-Taunus-Kreis. Somit kann suggeriert werden, dass eine ausreichend große Erfahrung in der Durchführung von Fortbildungen gegeben ist. Trotzdem war es nicht möglich, entsprechende Standards zu etablieren, obwohl gerade in der Versorgung von Notfallpatienten von der Standardisierung profitiert werden kann [5]. Je zeitkritischer die Versorgung eines Notfallpatienten ist, desto wichtiger ist ein strukturiertes Vorgehen anhand von Standards und Algorithmen [6,7].

Die Ausführung von Fertigkeiten und der damit verbundene Umgang mit entsprechenden Geräten und Ausrüstungsgegenständen hängen hinsichtlich der Sicherheit und Qualität von der häufigen und regelmäßigen Anwendung ab [8]. Beispielhaft sei hier die Intubation genannt, welche regelmäßiger Übung bedarf [9,10]. Trotzdem spielen Fertigkeitstrainings in der medizinischen Aus- und Fortbildung oftmals eine untergeordnete Rolle [11]. Insbesondere für Maßnahmen im Bereich der Traumaversorgung besteht kaum Routine. Besonders schwere Traumen gehören zu den seltenen Notfällen [12], wobei gerade hier in kurzer Zeit viele komplexe Prozesse und einzelne Fertigkeiten ausgeführt werden müssen. Gerade deswegen sollen die Übungseinheiten helfen, Defizite in den Fertigkeiten zu verringern und ein routinierter Umgang mit Geräten, auch in komplexen Situationen, zu festigen.

Die Tatsache, dass Feedbacks oder Einsatznachbesprechungen nicht stattgefunden haben zeigt nicht, ob Feedbacks durch die Notärzte nicht gegeben wurden oder auch von dem Rettungsfachpersonal nicht eingefordert wurden. Auch in der Notfallmedizin gehören Feedbacks zu den gewinnbringendsten didaktischen Instrumenten [13], welche im ambulanten Pflegebereich als Pflegevisiten fester Bestandteil des Qualitätsmanagements sind [14].

Die Prozessqualität rückt so als ein wesentlicher Indikator in den Vordergrund der prähospitalen Leistungen [4], lässt sich jedoch meist nur retrospektiv auswerten, um Erkenntnisse über die Prozessqualität zu erlangen. In Baden-Württemberg wird bereits die notärztliche Prozessqualität evaluiert [15] sowie in Systemen der Luftrettung. Im Bereich des nicht-ärztlichen Rettungsdienstes gibt es nur vereinzelte Auswertungen [3].

Eine richtige Supervision an der Einsatzstelle (Field-Supervisor) ist da dagegen meist nur in angloamerikanischen Rettungsdiensten verbreitet [16] oder zum Beispiel in Österreich etabliert [17]. Dieser hat die Aufgabe die Qualität vor Ort zu evaluieren, bei Schwierigkeiten zu helfen und zu vermitteln.

Trotz einer gesonderten zweitägigen Einführung und spezielle Schulung der Lehrrettungsassistenten in aktuellen didaktischen Konzepten haben sich die Mitarbeiter in den Fortbildungen schwer getan, verschiedene Strategien hinsichtlich der Selbsterarbeitung und Aufarbeitung von theoretischen Sachverhalten als Hintergrund zur praktischen, täglichen Arbeit anzunehmen. Im Gegenteil, die Bewertungen der Fortbildungen haben sich verschlechtert und die Zufriedenheit der Mitarbeiter hat abgenommen.

Die Einführung der standardisierten Kurskonzepte führt zunächst zu einer deutlichen Kostenzunahme. Für die entstehenden Mehrkosten der Fortbildungen kommen in Wiesbaden anteilig die Kostenträger auf.

Jedoch erscheint dem Rettungsdienstträger dieser Schritt als ebenso wertvoll, da PHTLS-Kurse mit aktuellen didaktischen Methoden vertraut sind und mit einem Teilnehmer-Instruktoren-Verhältnis von 3:1 eine effektive Ausnutzung der Kurszeit garantiert. Zu dem schult PHTLS eine klare Struktur in der Versorgung von schwerverletzten Patienten und zwar bereits weltweit in 54 Ländern.

Somit sind drei wesentliche Voraussetzungen erfüllt, nämlich die aktuelle didaktische Herangehensweise, eine

klare (und weltweit anerkannte) Struktur in der Versorgung von Notfallpatienten sowie eine extrem hohe Zufriedenheit der Teilnehmer von PHTLS-Kursen. Demzufolge werden 2013 alle Rettungsassistenten an einem zweitägigen PHTLS-Kurs teilnehmen. Die Eigenschaften der PHTLS-Kurse treffen ebenso auf die AMLS-Kurse zu.

Ergänzt um die Übungsdienste, wird gerade hier noch mal der nötige Umgang mit Geräten und Hilfsmitteln geübt. Um die Versorgung und die Prozessqualität in der Versorgung von Notfallpatienten zu gewährleisten, ist ein sicherer und auch technisch korrekter Umgang mit den eingesetzten Geräten und Hilfsmitteln unabdingbar [16,17].

Die Besonderheit bei diesem Projekt ist sicherlich, dass hier organisationübergreifend eine sehr große Anzahl von Mitarbeitern in unterschiedlichen Schwerpunkten geschult wird und zudem ein international zertifiziertes Kursprogramm als Fortbildung etabliert wird.

Zusammenfassung

Aus den festgestellten Problemfeldern in den Fortbildungen des Rettungsfachpersonals werden zusammenfassend folgende Projekte initiiert:

- Praxisrelevante Fortbildungen mit der Gewährleistung eines hohen Praxistransfers: Dazu werden die Fortbildungsprogramme PHTLS und AMLS genutzt, um eine gleichbleibend hohe Qualität in der Fortbildung für alle Mitarbeiter zu garantieren und um einheitliche Lehraussagen und Fertigkeiten zu übernehmen.
- Sicherer Umgang mit eigenen Geräten: Inhaltlich abgestimmte Übungsdienste sollen durch den Aufbau von Routine und Sicherheit in der Handhabung der Ausrüstung zu verbesserten Arbeitsabläufen in der täglichen Praxis führen.
- Evaluation der praktischen Arbeit: Über die Funktion des Einsatz-Supervisor soll jedem Mitarbeiter ein entsprechendes Feedback zu seiner Arbeit gegeben werden, um mögliche Schwächen, und bisher ungenutzte Potentiale aufzudecken.

Ziel dieser Maßnahmen ist es eine höhere Zufriedenheit des Personals zu erlangen, sowie die Qualität der präklinischen Versorgung zu steigern. Eine wissenschaftliche Auswertung wird sowohl über die Fortbildungen, wie auch über die geplante Supervision stattfinden. Festzuhalten bleibt, dass hier sehr vielschichtige Bemühungen zur Steigerung der Versorgungsqualität und damit zu einer besseren Patientenversorgung unternommen werden. Dies muss anerkennend dem Rettungsdienstträger, allen beteiligten Institutionen und auch den Kostenträgern konstatieren werden. Das größte Potential dürfte letztendlich aber bei den Mitarbeitern selbst liegen.

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2.2 Studienprotokoll

Häske D, Beckers SK, Hofmann M, Wölfl CG, Gliwitzky B, Grützner P, Stöckle U, Münzberg M (2014) The effect of paramedic training on pre-hospital trauma care (EPPTC-study): a study protocol for a prospective semi-qualitative observational trial. BMC Medical Education 2014 (Häske et al. 2014).

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STUDY PROTOCOL Open Access

The effect of paramedic training on pre-hospital trauma care (EPPTC-study): a study protocol for a prospective semi-qualitative observational trial

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Abstract

Background: Accidents are the leading cause of death in adults prior to middle age. The care of severely injured patients is an interdisciplinary challenge. Limited evidence is available concerning pre-hospital trauma care training programs and the advantage of such programs for trauma patients. The effect on trauma care procedures or on the safety of emergency crews on the scene is limited; however, there is a high level of experience and expert opinion.

Methods: I – Video-recorded case studies are the basis of an assessment tool and checklist being developed to verify the results of programs to train participants in the care of seriously injured patients, also known as "objective structured clinical examination" (OSCE). The timing, completeness and quality of the individual measures are assessed using appropriate scales. The evaluation of team communication and interaction will be analyzed with qualitative methods and quantified and verified by existing instruments (e.g. the Clinical Team Scale). The developed assessment tool is validated by several experts in the fields of trauma care, trauma research and medical education. II a) In a German emergency medical service, the subjective assessment of paramedics of their pre-hospital care of trauma patients is evaluated at three time points, namely before, immediately after and one year after training. b) The effect of a standardized course concept on the quality of documentation in actual field operations is determined based on three items relevant to patient safety before and after the course. c) The assessment tool will be used to assess the effect of a standardized course concept on procedures and team communication in pre-hospital trauma care using scenario-based case studies.

Discussion: This study explores the effect of training on paramedics. After successful study completion, further multicenter studies are conceivable, which would evaluate emergency-physician staffed teams. The influence on the patients and prehospital measures should be assessed based on a retrospective analysis of the emergency room data.

Trials registration: German Clinical Trials Register, ID DRKS00004713.

Keywords: Paramedic, Pre-hospital, Trauma, Training, PHTLS, Medical education

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Background

Accidents are the leading cause of death in adults prior to middle age [1]. A patient collective is concerned which could particularly benefit from rapid recovery after an accident. In addition to the personal suffering and loss of so-called human capital (in work and leisure activities), the economic costs are relevant and have an effect on the gross national product [2]. The economic costs of traffic accidents in Germany amount to 31 billion euros per year [3].

In recent years, there have been a number of indications of the importance of study findings concerning trauma care, including the following: 1) the introduction of regional trauma-networks [4,5]; 2) a White Paper from the German Trauma Society [6,7]; 3) increased training of emergency department teams [8] and training programs in emergency medical services [9]; 4) the establishment of the TraumaRegister DGU® of the German Trauma Society [10]; and 5) the German S3 – Guideline on Treatment of Patients with Severe and Multiple Injuries (2011) [1].

In the 1970s, "Advanced Trauma Life Support" (ATLS) introduced standardized treatment of trauma patients in emergency departments. Probable total of approximately 2 million physicians are trained in the program worldwide [11]. The global ATLS program is a condition for certification for trauma centers in Germany [12]. Münzberg et al. showed that since 2003, ATLS has performed with high ratings based on evaluation by the participants [11]. Based on the "lowest common denominator", ATLS is a concept for training the physicians dealing with severe injured patients in the emergency departments in Germany [13]. Ruchholtz et al. showed in the 1990s that procedures based on the guidelines could improve the care of emergency room patients [14]. Evidence of the effect on patient outcome is lacking [15].

The interface between emergency medical services (EMS) and emergency departments in the treatment of seriously injured patients benefits from uniform standards of care based on identical medical-scientific knowledge and communication with a "common language" to avoid errors and to improve priority-based patient care [16].

The treatment of severely injured patients is particularly challenging because these injuries are rare [17] and require multi-disciplinary team work and complex and comprehensive therapy [18]. Pre-hospital care is in parts associated with considerable technical effort.

The pre-hospital care of severely injured patients was essentially characterized in the past by the two following systems: "stay and play" or "load and go" [19]. In recent decades, pre-hospital trauma care has been supplemented by the findings of military medical treatment [20] and appear to approach each other [21].

Pre-hospital treatment has to establish the initial treatment strategies and be priority-oriented. The available data are inadequate, although field experiences and expert opinions are extensive.

The existing trauma care training programs such as the Pre-Hospital Trauma Life Support (PHTLS) or ATLS programs lead to more subjective safety levels of the participants regarding the care of trauma patients [22,23]. The extent of the effect of this training on the quality of the process and especially on the quality of the primary outcomes of modern EMS systems is not clear [24]. The introduction of a training program such as PHTLS in less developed systems results in a measurable change [25]. Studies that evaluated the outcome of patients after rescue and treatment according to the PHTLS standards have shown no significant advantage over currently established principles of trauma care [26,27]. Standardized training programs such as PHTLS are increasingly integrated into the training or education of EMS staff [28,29]; however, the differences in the current standard of care from the recommendations of PHTLS are unknown. A concrete comparison of the PHTLS content with the current guidelines for the treatment of multiple traumas is pending.

The participants evaluate PHTLS courses very positively, although there are no published evaluations. A subjective assessment by the participants was collected after the PHTLS TEAM (PHTLS at medical school) training, which suggests an improvement in the scenario based on the care of severely injured patients [23]. Particularly in the area of "non-technical skills", various assessment instruments have been developed that assess communication, team interaction, and decision making [30-34].

There is no suitable measuring instrument to ensure the effect of training objectively like the processes, strategic decisions, skills and medical aspects of treatment.

This study will evaluate the effect of PHTLS courses on the participants because its effect on patient outcome as known is not measurable.

Hypotheses

Using a novel assessment tool (2.4.1), the following hypotheses will be tested:

- The introduction of PHTLS leads to improved quality of the documentation of actual field operations.
- The introduction of PHTLS leads to structured patient care by the ABCDE scheme [35], with priority-based interventions in case-based scenario training.
- The introduction of PHTLS leads the participants to a subjectively better and safer application of the principles.

Trial design

This trial is designed as an interventional, single arm – uncontrolled, open study. It is a single-center, prospective, semi-qualitative observational trial.

Methods

Study setting

The study is performed in the EMS of the city of Wiesbaden and Rhein-Taunus-Kreis (Germany). The operational area in Wiesbaden has five commissioned EMS agencies (four charities, one private provider). The EMS in Wiesbaden has 375 paramedics and serves 462 098 inhabitants.

With regard to the training, close cooperation occurs with the neighboring Rheingau-Taunus-Kreis area. In the context of various difficulties and problems, the controlling authority enabled 301 paramedics from both EMS services to attend the PHTLS courses to create uniform structures and principles [28].

Eligibility criteria

Included in the study are all the employed paramedics and emergency medical technicians (EMTs) of the participating institutions (ASB, DRK, MHD, private) of the emergency medical services of Wiesbaden and Rheingau-Taunus-Kreis. Excluded are all the participants not involved with the participating institutions.

Interventions

Paramedical personnel are trained in the care of trauma patients, and the worldwide standardized and certified training program "PHTLS" (Pre Hospital Trauma Life Support) is used.

PHTLS provider courses focus on the professional groups involved in EMS (EMT, paramedics, emergency physicians) for the pre-hospital care of trauma patients and are currently well established in Germany. Among other participants, the helicopter crews of the DRF German Air Rescue will be trained in PHTLS, as well as the German armed forces, which have established PHTLS courses for mission preparation. Thus, PHTLS courses are merged seamlessly with ATLS courses for clinical care in emergency departments [8].

The central link between the PHTLS and ATLS courses is uniform communication and the priority-based approach [22].

In the two-day courses, the participants obtain a complete procedure for the structured treatment of trauma patients, in addition to trauma-specific skills; the classes conclude with a written and practical exam.

PHTLS courses are characterized by the extensive variety in the teaching methods (lectures, practical case studies), with a close instructor- participant ratio (1:3), many practice activities and continuous interaction.

In addition to various skills, the priority-based structure, ABCDE (Airway, Breathing, Circulation, Disability and Exposure), is taught and practiced in scenario-based training sessions. The "ABCDE" method provides structure for patient treatment and ensures that other therapeutic measures are objectified [15].

The PHTLS manual (2nd German edition), which forms the basis for the German PHTLS courses [35], is sent to the participants before the course and is intended to provide the course content with the following priorities:

- Safety for EMS staff and patients
- Involvement of the accident kinematics in the assessment
- Priority-based treatment-principles, "treat first what kills first"
- Rapid and correct c-spine immobilization
- Immediate repair of airway (A) problems
- Evaluation of the ventilation, rapid oxygen administration and treatment of tension pneumothorax
- Stop external bleeding and minimization of internal bleeding, e.g. with the pelvic sling
- Positioning of axis fractures, and immobilization of the patient if necessary
- Treatment of hypothermia
- Insertion of iv-lines and fluid resuscitation
- Neurological assessment with GCS (Glasgow Coma Scale) and pupil status
- Team communications with clear instructions and early clarification to the receiving hospital

As part of the so-called secondary survey, the PHTLS courses provide a SAMPLE scheme with **s**ymptoms, **a**llergies, **m**edications, **p**atient history (including the medical history), the **l**ast oral intake and information about the **e**vent that led to the emergency situation.

The PHTLS courses require a baseline-scenario at the beginning of the course, in which the participants treat a patient in a standardized scenario-based case, without help or feedback from the instructors. The participants obtain an impression of their work before the course. During the second day, a clear shift towards a structured treatment is typically recognized.

Outcomes

Three outcome measurement methods are used:

Assessment tool

The Assessment-Tool has to be used to evaluate objectively the processes and skills during the scenarios. This method is also applied as "objective structured clinical examination" (OSCE) in medical schools [36-39] and used in emergency medical education, too [40,41]. The assessment tool will be designed for the video-based outcome measurement with defined endpoints.

The assessment tool shall take into account three main aspects:

- The educational content of the PHTLS courses including oxygen administration, c-spine immobilization and treatment algorithms.
- Established assessment instruments such as the Clinical Team Scale (CTS) for the validation of teamwork, team communication and clinical decision making.
- Aspects, which are noticeable in the analysis of the scenarios.

Verifiable items are developed from the PHTLS curriculum and from the established measurement instruments, which can be assessed and quantified using an instrument such as the Likert Scale.

Various video-recorded scenarios are used to perform a qualitative content analysis in a non-reactive observation. The relevant features are clustered and transcribed to obtain quantifiable items.

The items are evaluated independently of the measurement scale and summarized as a total score. The fulfilled items will be chronologically registered to analyze the diagnosis procedure and interventions.

Validation of the assessment tools with regard to objectivity and reliability should be based on two scenarios by experts in the fields of emergency medicine, medical education and traumatology. The number of experts will result in a ratio of the items.

The inter-rater reliability, which is the degree of agreement among the experts in the application of the assessment tool, can be verified using Fleiss' kappa correlation, for which a significance level is set.

Questionnaire

The course participants are interviewed with a questionnaire concerning their level of knowledge, skills and safety in the care of trauma patients. These data are collected multiple times and reflect the participants' subjective assessment of learning success in knowledge, skills and safety. A steady (metric) scale to ± 3 (positive/negative), including zero is used.

EMS-operation protocol

As part of the so-called "secondary survey", the PHTLS courses provide use "SAMPLE" as a mnemonic tool [36]. The letters "AMP" stand for allergies, medication and patient history and are relevant to patient safety [42]. The analysis will review these features in the standardized EMS protocols from actual field operations performed by paramedics, if after the course (not only in trauma patients) the SAMPLE history is used.

The state of Hessen uses the so-called report digits ("Rückmeldezahlen, RMZ"), which report encoded medical indications (e.g. combustion, hyperventilation) and the patient's condition by a return code "RMC"(Rückmeldecode) and timestamps. The RMC documents a seven-item array consisting of the consciousness, respiration, circulation, injury, neurology and pain of the patient. The minimum number of points of the RMC is six; the maximum number of points is 42. Deviations from the physiological condition of the patient arise from an RMC > 6 points. There is no validation of the correct assessment or use by the paramedics. The extracted identification numbers of the operations are available from the period before the first course started. The identification numbers of the operation-protocols will be randomly selected from the quarter prior to the start of the course. The protocols are selected for the involved EMS agencies proportional to their level of participation in the total operations. The RMC must be greater than 6 points, and selected protocols will be analyzed.

The second analysis is scheduled in the quarter after all of the participants have completed the courses. The frequency of the fulfilled mnemonic is thus compared before and after the implementation of the PHTLS courses.

Data from the emergency department

In addition to actually study design, we will evaluate in a retrospective analysis the emergency department data. The investigation is and will be integrated regarding to detailed question and basic circumstances (e.g. ethics application, data privacy). Outcome measurement methods are developed.

Bias

In the before-after comparison, the participants know the approach to the patient through other training as well as that taught by the PHTLS. Even reading the PHTLS manual to prepare for the course might influence the participants, as would the fact that with each additional course, knowledge is disseminated by colleagues.

The cohorts of participants are paramedics. Typically, a German EMS crew does not treat seriously injured patients alone because paramedics are supported by emergency physicians in the field. Specific types of invasive skills and analgesia must be excluded from the cases because they are not performed by paramedics in the analyzed area.

Mimes For the baseline scenario, a participant performs the role of the patient; for the case studies, an instructed mime performs a standardized role of the patient. The quality of the representation and the accurate reproduction of specified symptoms might differ under those conditions.

Instructors The vital signs and the non-presentable values are specified by the instructors. Each scenario could be defined differently or be variably stressed. Typically, the scenarios last approximately 10 minutes and

are led by the instructors, and the team communication might be limited.

Participants The participants begin the course with different levels of motivation. They should have the identical theoretical knowledge level because they have read the PHTLS manual by the start of the course.

A type of Hawthorne effect may be caused by the fact that the participants know that they are being observed and might be filmed. Regarding the video recording, it is assumed that the more motivated participants offer to be the first team for the scenarios. If the identical participants are also used for the second video recording, the result might not be the result for the study cohort.

Technical and organizational aspects It is possible that the participants did not provide their consent to the recording. Technical problems could affect the video recordings. Organizational difficulties with the equipment (including unpunctual delivery loss of volume) and organizational fault in the recordings (wrong scenario, a bad camera position) might be possible.

Timeline

There are three defined time points for the measurement (Figure 1), as follows:

Timepoint t0

Immediately prior to the PHTLS course (pre-course), the participants are interviewed with the questionnaire about their personal judgment regarding their skills, knowledge and safety in the care of trauma patients.

Prior to the start of the training program, the participants in 3-person-team treat a trauma-patient in a standardized case-based scenario, which is recorded on video. Additionally we want to evaluate the emergency department data from 2012.

Timepoint t1

At the end of the course, the participants' survey with the questionnaire and the video recording are repeated to verify the changes (post-course).

Timepoint t2

After one year, the participants of the course will be interviewed again with the questionnaire, and the results will be verified by the video recordings in standardized case-based scenarios in practice. Data from the emergency department will be from 2014.

Number of participants

Questionnaire

The number of questionnaires is based on the number of participants. The questionnaires at t0 and t1 will be collected directly, and a 100% return rate is expected. The questionnaire at time t2 will be web-based or distributed via email.

Video recording

In the 14 planned courses, 4 video recordings of scenarios completed by three-person teams will be made at t0. A total of 56 teams (168 participants) will be recorded. At t1, video recordings will be made. At this point, three records will be possible, and 12 teams per course will be filmed. In 14 courses, we expected up to 168 teams. The recordings will be made with four camcorders (Panasonic HD Camcorder HC-V100) and recorded on SD Memory Cards.

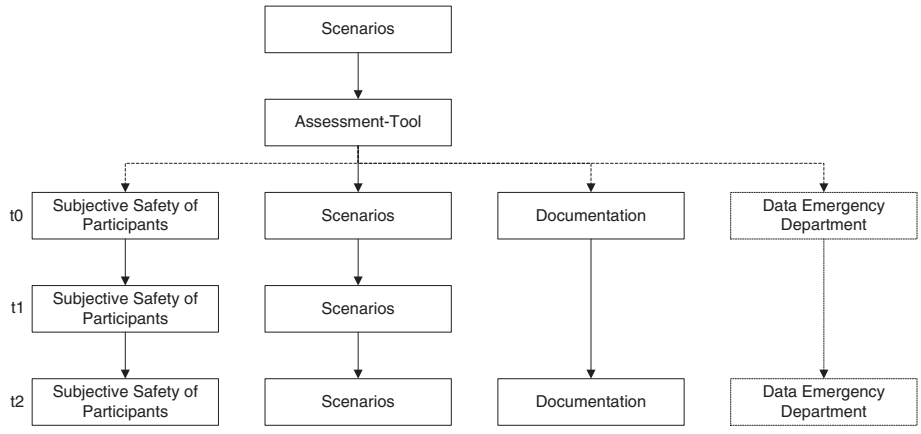

Figure 1 Project timepoints t0 - t2. "Subjective Safety of Participants" and "Scenarios" with three time points. Documentation with two time points. "Data Emergency Department" in process of planning.

No.	Task	begin	issue
1	Projectdesign, conference involved institutions	01.08.2012	31.10.2012
2	Design questenaire	01.10.2012	31.12.2012
3	Statistics, ethic approval, data privacy	01.01.2013	28.06.2013
4	Videorecordings, questionaires during the courses time t0 und t1	01.01.2013	31.12.2013
5	Design assessment-tool	01.07.2013	30.05.2014
6	Analysis operation-protocol 2012	01.10.2013	31.12.2013
7	Data Emergency Department, Design and Statistics	15.11.2013	31.03.2014
8	Videorecordings, questionaires during the courses time t2	01.01.2014	31.12.2014
9	Data editing, preparation questionaire for analysis t0 und t1	01.01.2014	30.04.2014
10	Validation assessment-tool	03.03.2014	30.06.2014
11	Data Emergency Department, Analysis 2012	01.04.2014	30.09.2014
12	Analysis operation-protocol 2014	01.05.2014	29.08.2014
13	Analysis videorecords	01.10.2014	30.07.2015
14	Analysis questonaire	01.01.2015	30.03.2015
15	Data Emergency Department, Analysis 2014	01.01.2015	01.06.2015

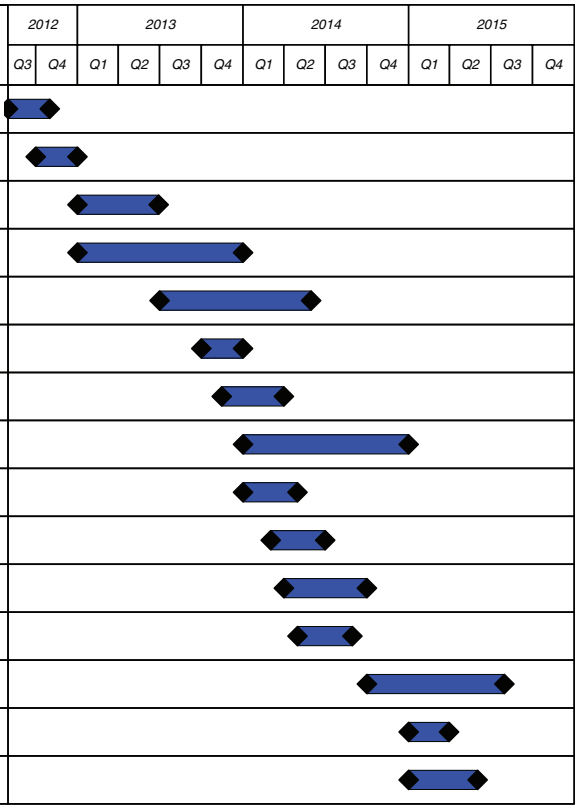

Figure 2 Flowchart of the study, with detailed issues and tasks.

EMS operation protocols

Experts from the Department of Biometry of the University of Tuebingen Hospital (Tuebingen, Germany) recommended the evaluation of 400 protocols to detect changes of approximately 10% at a power of 0,8.

Data from the emergency department

pending

Recruitment

The medical supervisor and the EMS agencies require the participants to attend the training. Study participation is voluntary.

Data collection methods

Questionnaire

The questionnaires at t0 and t1 are distributed and collected during the courses. The survey at t2 (after one year) is conducted using the questionnaires in parallel with the video analysis.

Video recording

The videos are recorded at the beginning and end of the training and one year later.

EMS operation protocols

The EMS protocols are required in the context of the EMS field operations and archived in the EMS agencies in concordance with the local EMS regulations.

Data from the emergency department

pending.

Data management

The data collection, coding, routing and analysis are coordinated with the data protection officer of the University of Tuebingen and the University of Tuebingen Hospital. The participants will be informed about the study prior to the course, and their questions about it will be answered.

The declarations of consent from the participants for the video analysis are available; the consent declarations assure permission for the recording, analysis and storage of the study data. The number of participants will be registered as a negative figure.

For the questionnaires and time contact, t2 is a declaration of consent for the available participants. This declaration is separated from the questionnaires on site. The questionnaires are pseudonymized with a four-digit code to represent the relationship between the different times, not to establish a connection to the participants.

The analysis of the defined characteristics in the EMS-operation protocols is unrelated to the patient data (including the last name, first name and date of birth). Hessian EMS law § 17 permits the use of evaluation data in the context of quality assurance.

Statistical methods

The statistical analysis of the end points of the video is based on the assessment tool. The achievable sum scores from the assessment tool are combined with the respective measuring points and, depending on the scale levels, as the mean or median and compared as the independent samples. The statistical tests are dependent on the scale level, and the results are given with the confidence intervals.

The statistical analysis of the questionnaires used the three time points t0, t1 and t2. The individual questionnaires at the respective time points are recorded using Microsoft Excel® 2010 (Redmond, USA). The data are matched in IBM SPSS Statistics 21 software (Illinois, USA) with the pseudonymous ID codes. The data are normally distributed and considered to be metric; the statistical calculation was performed using Student's t-test for the unpaired two-sided sampling. The significance level is set at $\alpha = 0.05$.

The evaluations of the EMS protocols in terms of three items, allergies, medication, and the patient's medical history are conducted by counting the frequency before and after the comparison. The significance level is set at $\alpha = 0.1$.

Research ethics approval

The Ethics Committee of the Medical Faculty of the Eberhard Karls University of Tuebingen and the University Hospital approved the study proposal, number 197/2013BO2, on May 24 2013. The study is registered in the German Clinical Trials Register with the ID DRKS00004713.

Trials status

The video recordings as well as the basics of the program and the development of the assessment tools are in process (Figure 2).

Discussion

The aim to evaluate the effect of the training or the effect of the program on the patient outcome is understandable, complex and difficult. This study attempts to evaluate the effect of the training on the participants' behavior.

This is a single-center study and based on scenarios of the treatment given to patients by paramedics. There is interest in developing a multi-center assessment tool. Concrete efforts will be made after the completion of this study to apply the tool for evaluation of emergency physician-based teams including air rescue personnel.

We are aware that the video analysis is influenced by a variety of factors. In addition, the result of the scenario-based patient care is not to transfer 1:1 to the real patient care. To increase the comparability and consistency, a member of the research group will supervise the recordings or even leads them through. Time t0 records are parallel, and the scenarios are directed by leading instructors briefed on the key points and identical criteria to apply to all the cases. An identical situation occurs with t1, with the difference being that in t1, the cases are sequential instead of parallel.

Initially it was planned to visualize the individual measures on a timeline. However, the flow in the scenario is disturbed by the information from the instructors, for example vital signs or by questions from the participants, so it does not seem sensible to use the real-time analysis. In addition, a range of skills such as laying intravascular access or prepare infusions are not real performed.

The results of the questionnaire for the subjective assessment of the participants should be available without special bias, especially we expect a very high response rate. The evaluation of the EMS-protocols focuses on three items, which are trained in the course. But since the SAMPLE scheme is widely used, it remains to be seen how the degree of compliance prior to the course and a possible change is measurable.

This study is being extended to encompass a retrospective analysis of the emergency department data because the participants report a significant change in the care of trauma patients in actual field operations. A question remains concerning the degree to which the training of paramedics in PHTLS has an effect on the treatment of trauma patients by emergency physician-supported teams. Key points will be pre-hospital on-scene time, measures and treatment, and any changes in the patient collective. This part is not completed.

Abbreviations

ASB: Arbeiter-Samariter-Bund, German aid and welfare organization, EMS agency; ATLS: Advanced trauma life support; DRF: Deutsche Rettungsflugwacht, German Air Rescue; DRK: Deutsches Rotes Kreuz, German Red Cross, a non-profit organization, EMS agency; EMS: Emergency Medical Service; EMT: Emergency medical technician; JUH: Johanniter Unfallhilfe, German Aid and Welfare Organization, EMS agency; MHD: Malteser Hilfsdienst, German Aid and Welfare Organization, EMS agency; PHTLS: Pre-Hospital trauma life support.

Competing interests

DH, MM, CW are PHTLS instructors. BG is the Chairman of PHTLS Germany and Manager of the DBRD-Akademie GmbH. The other authors declare that they have no competing interests. The study is funded by the German Association of Emergency Medical Technicians (Deutscher Berufsverband Rettungsdienst e.V. DBRD). Further fundings are requested. There is no influence in the study design, data collection and analysis, decision to publish, or preparation of the manuscript by the sponsors.

Authors' contributions
DH is the principle investigator of the study, developed study design, drafted the protocol and did the final writing. SB, MH assistant to develop study design, assistant in development protocol, reviewed final writing and gave expert tips. MM assistant to develop study design, reviewed final writing and gave expert tips. CW, US, PG gave expert tips. All authors read and approved the final manuscript.

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2.3 Vergleich der PHTLS-Lehraussagen mit der S3-Polytraumaleitlinie

Häske D, Stuke L, Bernhard M, Heller AR, Schweigkofler U, Gliwitzky B, Münzberg M (2016) Comparison of the Pre-hospital Trauma Life Support (PHTLS) Recommendations and the German National Guideline on Treatment of Patients with Severe and Multiple Injuries. The journal of trauma and acute care surgery 81: 388–393 (Häske et al. 2016).

Comparison of the Prehospital Trauma Life Support recommendations and the German national guideline on treatment of patients with severe and multiple injuries

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BACKGROUND: The Prehospital Trauma Life Support (PHTLS) concept is well established throughout the world. The aim is to improve prehospital care for patients with major trauma. In 2011, a German Level 3 (S3) evidence- and consensus-based guideline on the treatment of patients with severe and multiple injuries was published. The scope of this study was the systematic comparison between the educational content of the worldwide PHTLS concept and the German S3 Guideline.

METHODS: A total of 62 key recommendations of the German S3 Guideline were compared with the content of the English PHTLS manual (eighth edition). Depending on the level of agreement, the recommendations were categorized as (1) agreement, (2) minor variation, or (3) major variation. Comparison was done via a rating system by a number of international experts in the field of out-of-hospital trauma care. The Delphi method was used to get the final statements by indistinct or board-ranged ratings.

RESULTS: Overall, there was no conformity in 12%. In 68% a total agreement and in 88% conformity with slight differences of minor variations were found between the key recommendations of the guideline and the PHTLS manual. The PHTLS primary assessment has a large conformity for the following individual priorities: airway, 92%; breathing, 92%; circulation, 63%; disability, 100%; exposure, 89%.

CONCLUSIONS: According to our comparison, the PHTLS manual is largely compatible with the German S3 Guideline from 2011. The 12% divergent statements concern mainly fluid resuscitation. Minor deviations in the prehospital care are due to a national guideline with an emergency medical service with emergency physicians (S3 Guideline) and a global PHTLS concept. (*J Trauma Acute Care Surg*. 2016;81: 388–393.

KEY WORDS: EMS; evidence-based medicine; injury; out-of-hospital treatment; trauma patients.

In the 1980s, Advanced Trauma Life Support (ATLS)[1] was developed as a concept to treat patients in the trauma bay. Prehospital Trauma Life Support (PHTLS)[2] followed some years later as a prehospital concept, modeled after the successful ATLS program. Both courses have successfully promulgated worldwide and are standards in interdisciplinary acute trauma care today.

The ABCDE algorithm (airway and C-spine protection, breathing, circulation, disability, exposure) is not only an established scheme of different courses and medical trainings, but also the core component of PHTLS and ATLS.

In July 2011, a Level 3 (S3) evidence and consensus-based guideline on the treatment of multiply injured trauma patients was published in Germany.[3] This guideline refers to clinical symptoms, corresponding measurements and treatments, and a care strategy, which is based on scientifically reliable data from which appropriate recommendations can be pronounced.[3] The guideline was divided into an out-of-hospital and in-hospital section.

In Germany, PHTLS was introduced in 2007 by the German Association of Paramedics (DBRD), supported by the German Trauma Society (Deutsche Gesellschaft für Unfallchirurgie [DGU]), German Society of Anesthesiology and Intensive Care Medicine, and Professional Association of German Anesthetists. Especially in the early stage, there were a lot of reservations and doubts. The most common objection was that the German double response emergency medicine services (EMS) system staffed with out-of-hospital physicians and paramedics differed too much from the American paramedic system and that the discrepancies of infrastructure in the prehospital healthcare were too large. Nevertheless, PHTLS has become over the last years a generally accepted training program for all providers (paramedics and out-of-hospital physicians) in the EMS system around Europe.

The German S3 Guideline is considered the professional basis for trauma care in Germany and is recognized as the criterion standard by all participants in the EMS. Therefore, the conformity of PHTLS with the German S3 Guideline is very important for the further acceptance of PHTLS in Germany.

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Our hypothesis is that the course content of PHTLS coincides largely with the German S3 Guideline. The aim of this study is a systematic comparison between the German S3 Guideline key recommendations and the PHTLS principles.

METHODS

German S3 Guideline on Treatment of Patients With Severe and Multiple Injuries

The German S3 Guideline on Treatment of Patients With Severe and Multiple Injuries[3] was developed under the direction of the German Trauma Society (DGU). The S3 Guideline is a highly evidence-based and also consensus-based tool. It is based on the current state of scientific knowledge and on procedures proven in practice.

The representatives of the participating societies drafted a total of 264 key recommendations, as recommended for a Level 3 guideline formation. The guideline cites the prehospital, the trauma bay, and the initial surgical phase. This S3 Guideline includes formal consensus finding, systematic literature search, evaluation and classification of studies, and recommendation according to the criteria of evidence-based medicine, clinical algorithms, outcome analysis, and decision. This strategy follows in all aspects a systematic development. Based on the evidence classification of the Oxford Center of Evidence-Based Medicine,[4] the authors of the chapters selected and evaluated the literature. Three grades of recommendation (GoR) were used. The key recommendations are divided in "shall" (A), "should" (B), or "can" (0) as appropriate. To determine the GoR, further to the evidence, the clinical expertise of the experts[3] was considered. In addition to the core statements, the guideline contains important explanations on the recommendations and their estimation.

Prehospital Trauma Life Support: The Eighth Edition

Prehospital Trauma Life Support is the recognized standard for prehospital trauma care in 66 countries throughout the world. Prehospital Trauma Life Support combines professional consensus and didactic concept in order to enable efficient training to the course participants.

Prehospital Trauma Life Support represents the prehospital variant of the ATLS concept developed by the American College of Surgeons.[1] Based on the ATLS foundation, the PHTLS concept was developed by the National Association of Emergency Medical Technicians PHTLS Committee and endorsed by the Committee on Trauma of the American College of Surgeons. The PHTLS textbook is based on the ATLS manual[5] but is a separate textbook written by experts in prehospital trauma care and based on current prehospital literature and practices.[2]

Comparison Between the S3 Guideline and the PHTLS Manual

The 62 key recommendations of the chapter "prehospital" of the S3 Guideline were compared to the teachings of the PHTLS textbook (eighth edition). The corresponding distribution of GoR is shown in Table 1.

TABLE 1. Modified Classification From Münzberg et al.[6]

Agreement	The key recommendations of the S3 Guideline and the PHTLS manual are identical
Minor variation	Slight differences or lack of limit values between S3 Guideline and PHTLS manual
Major variation	Marked differences between S3 Guideline and PHTLS manual—clear contradiction
No statement	The PHTLS manual contains no statement on a key recommendation made in the S3 Guideline

For each recommendation of the S3 Guideline, two authors (D.H., M.M.) searched a matching statement in the PHTLS manual. The comparisons between the key recommendations S3 and the PHTLS manual were performed by 12 international experts in the field of emergency and trauma medicine, anesthesiology, surgery, evidence-based medicine, and didactics. They evaluated the findings individually with the use of an Internet-based scoring system and pointed out the variations.

The classification we used for the statements had already been used in the comparison with ATLS by Münzberg et al.[6] Statements were taken as "in agreement," if the teachings of PHTLS agreed with the S3 key recommendations. Conversely, if slight differences or inaccurate statements were recognized, the statement was recorded as a minor variation. All the other statements showing significant differences were classified as "major variation." Key recommendations that were not considered in the PHTLS manual were marked but were ultimately not assessed (no-statement group).

We regarded the variation groups as ordinal scaled variables and calculated the conformity of the experts with the median (3 = in agreement, 2 = minor variation, 1 = major variation, 0 = no statement). If the range of the evaluation of the experts included more than two classifications per statement or if the rating result was very narrow, we determined that these statements needed to be re-evaluated by the experts in a Delphi method. Based on this result, the authors defined the final statement.

Statistical Analysis

The concordance of the expert assessment was calculated with SPSS statistical software, version 23 (IBM Corp, Armonk, NY) by Fleiss κ for multiple raters. Classification according to McHugh[7] was defined as follows: 0 or less as no agreement, 0.01 to 0.20 as none to slight, 0.21 to 0.40 as fair, 0.41 to 0.60 as moderate, 0.61 to 0.80 as substantial, and 0.81 to 1.0 as perfect agreement; $p < 0.05$ was considered to be statistically significant.

RESULTS

In the first round of the expert rating, we had n = 36 (58%) "agreement," n = 18 (29%) "minor variation," and n = 5 (8%) "major variation." For three statements of the German S3 Guideline, no correlating PHTLS statements were found. Fleiss κ was 0.236 (fair) ($p < 0.001$; 95% confidence interval, 0.215–0.715).

Six statements were discussed in the Delphi method as the raters were more than two categories apart. One statement was discussed because the 12 raters voted 6:6 for two different

categories. Re-evaluation using the Delphi method upgraded five statements from the minor-variation group to the agreement group, one statement from the minor-variation group was corrected into the major-variation group, and one recommendation from the no-statement group was adjusted into the major-variation group.

According to the Delphi method, the final results were n = 42 (70%) "agreement," n = 11 (18%) "minor variation," and n = 7 (12%) "major variation," based on 60 comparable statements (Fig. 1). Two statements of the German S3 Guideline were without a corresponding PHTLS statement.

Regarding the GoR, GoR A has the highest correlation with "agreement" (n = 21), followed by GoR B with "agreement" (n = 18) (Table 2).

Table 3 shows the distribution of agreements in ABCDE primary assessment categories. The closest match is given in "disability" with 92% (n = 11), whereas the section "circulation" has the most variations with 31% (n = 5).

DISCUSSION

The result of the present study shows a considerable agreement between the teachings of PHTLS and the recommendations of the S3 Guideline on Treatment of Patients With Severe and Multiple Injuries, and therefore a good applicability in the German EMS is given. Overall, 88% of recommendations in the German S3 Guidelines and PHTLS are in agreement or have only minor variations. The 12% divergent statements concern mainly fluid resuscitation and reflect the different German S3 and worldwide PHTLS treatment approaches.[3] The proof of reliability with low Cohen κ confirmed the chosen methodological approach to discuss the first results of the comparison in a Delphi process and set the final score.

The comparison of the two guidelines showed that some recommendations, although aiming at the same treatment, are far more detailed in the one or in the other guideline, which often resulted in "minor variation" in our study. One example is the comparison of the S3 Guideline and PHTLS key recommendation on blood pressure in patients with traumatic brain injury. While the S3 Guideline recommends, without detailed values, maintenance of normotension for traumatic brain injuries (GoR B), the PHTLS guideline clearly mentions preserving a systolic value greater than 90 mm Hg. Even though both guidelines have nearly the same substantive focus, the S3 Guideline leaves more space for individual therapy requirements; for example, what can be interpreted in an (elderly) per se hypertensive patient in the concept of "normotension"?

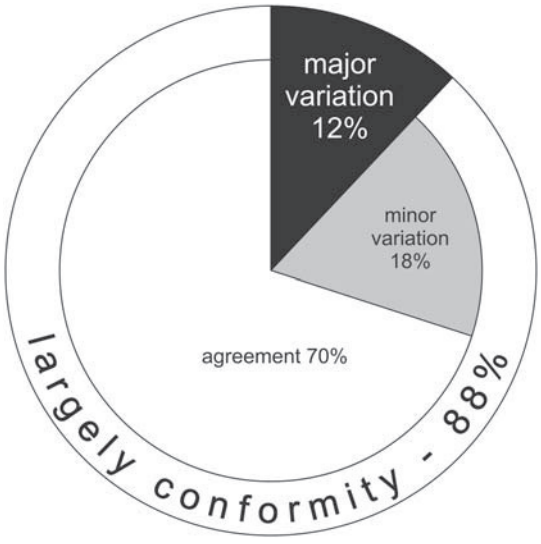

Figure 1. The PHTLS manual is in 88% compatible with the German S3 Guideline 2011. The 12% divergent statements concern mainly fluid resuscitation.

TABLE 2. Comparison Between the Grade of Recommendations GoR and the Ratings

	Agreement	Minor Variation	Major Variation	No Statement
GoR A	21	3	0	1
GoR B	18	7	6	1
GoR 0	3	1	1	0
Total	42	11	7	2

The intubation indications (GoR B) between the PHTLS manual and S3 Guideline differ in some details. Here, the S3 Guideline is more specific than the PHTLS recommendations regarding the indication for invasive airway management (e.g., intubation of the trachea) with the following recommendations: hypoxia (Spo_2 <90%) after supplement of oxygen while exclusion of tension pneumothorax, severe traumatic brain injury (Glasgow Coma Scale score <9), and severe chest injury with respiratory insufficiency breathing (rate >29 breaths/min).[8] Prehospital Trauma Life Support is less specific in its indications for intubation, stating "patient who is unable to protect his/her airway, significant oxygenation problem, requiring administration of high concentrations of oxygen, or patient with significant ventilator impairment requiring assisted ventilation."

The importance of education and continuous training of skills in airway management is pointed out by the PHTLS and the S3 Guideline with GoR A. Sufficient experience and training for out-of-hospital physicians or paramedics cannot be maintained by just participating in EMS, emergency operations, and emergency duties.[9–12] Findings from current studies on the learning curve for endotracheal intubation,[12] alternative methods to secure the airway (e.g., laryngeal tube, laryngeal mask),[10,11] and first-pass intubation success[12] underline the need for continuous retraining.

The use of etomidate as a sedative agent in emergency medicine has been a controversial issue for years.[13] It is not

TABLE 3. Comparison Between the PHTLS Primary Assessment and the Ratings

	Agreement	Minor Variation	Major Variation	No Statement
Airway	9	3	1	0
Breathing	9	2	0	1
Circulation	9	1	5	1
Disability	11	1	0	0
Exposure	4	4	1	0
Total	42	11	7	2

TABLE 4. Description of the Main Differences Between S3 Guideline and the PHTLS Eighth Edition Manual

Subject	German S3 Guideline	PHTLS (Eighth Edition)	GoR	Difference
Etomidate	Etomidate should be avoided as an induction agent because of the associated adverse effects on adrenal function (ketamine is usually a good alternative here)	Etomidate is mentioned in the table "Common Drugs Used for Pharmacologically Assisted Intubation" without regard to adverse effects on adrenal function. Ketamine has also been recommended	GoR B	Opposing recommendation
Fluid resuscitation	Isotonic saline solution should not be used; preference should be given to Ringer's malate, or alternatively Ringer's acetate or lactated Ringer's solution	As blood is usually not available in the prehospital setting, lactated Ringer's or normal saline is used for trauma resuscitation. The best crystalloid solution for treating hemorrhagic shock is lactated Ringer's solution	GoR B	Different recommendations
Fluid resuscitation	If colloidal solutions are used in hypotensive trauma patients, preference should be given to hydroxyethyl starch 130/0.4	Virtually no research exists involving the use of these synthetic colloid solutions in the civilian prehospital setting, and no data exist on their use in the hospital that shows them to be superior to crystalloid solutions. These products are not recommended for the prehospital management of shock	GoR B	Different recommendations
Fluid resuscitation	Hypertonic solutions can be used in multiply injured patients with hypotensive circulation after blunt trauma	An analysis of several studies of hypertonic saline failed, however, to demonstrate improved survival rates over the use of isotonic crystalloids. This solution is not FDA approved for patient care in the United States	GoR 0	Different recommendations
Fluid resuscitation	Hypertonic solutions should be used in penetrating trauma if prehospital volume replacement is carried out	An analysis of several studies of hypertonic saline failed, however, to demonstrate improved survival rates over the use of isotonic crystalloids. This solution is not FDA approved for patient care in the United States	GoR B	Different recommendations
Fluid resuscitation	A hypertonic solution can be used in hypotensive patients with severe traumatic brain injury	A randomized trial of patients with severe traumatic brain injury showed that those who received prehospital resuscitation with hypertonic saline had almost identical neurologic functioning 6 mo after injury compared with those treated with crystalloid. Because of its increased cost and lack of benefit compared with normal saline or lactated Ringer's solution, hypertonic saline is not recommended for routine prehospital volume replacement	GoR 0	Different recommendations
Bladder catheterization	In case of a suspected urethral injury, prehospital bladder catheterization should not be carried out	Even though insertion of a urinary catheter is not usually required in rapid transport circumstances, monitoring urine output is an important tool that can help guide decisions regarding the need for additional fluid therapy during prolonged transport. Insertion of a urinary catheter, if local protocols permit, should be considered so that urine output can be monitored	GoR B	Different recommendations

particularly surprising that guidelines designed by two different institutions assess the underlying study data and evidence diametrically different and therefore lead in this comparison to a major variation (Table 4). While PHTLS recommends the use of etomidate in patients with trauma, the S3 Guideline comes to the conclusion that etomidate should be avoided because it might cause a reversible adrenal insufficiency (GoR B). Ketamine is recognized as an alternative agent by both groups. A recent review summarizes once more the available evidence:[14] based on the current study situation and the uncertain assessable pharmacological literature for etomidate regarding to the long-term effect of a single application as part

of the induction of anesthesia on mortality, duration of ventilation, time spent, and infection rates, etomidate should be limited to the application in randomized controlled trials. Recent studies have evaluated ketamine as an alternative to etomidate with comparable good effect on the hemodynamic profile and the adjustability of the vocal cord during endotracheal intubation procedures.[15]

Both PHTLS and the S3 Guideline regard the needle decompression of tension pneumothorax as an important measure (GoR A). The S3 Guideline recommends a thoracostomy with or without a chest drain after every decompression, whereas PHTLS is critical toward the thoracostomy as it requires time and a certain training level and carries a risk of complication and infection.

By contrast, the treatment of pneumothorax results in a minor variation. The S3 Guideline recommends that pneumothorax should be treated with a chest tube (GoR B), while, interestingly, since the eighth edition of PHTLS, the chest drain is prehospital optioned for specialized personnel (e.g., air rescue) in pneumothorax.

The potential reason for this "minor variation" is the various prehospital systems (paramedic vs. out-of-hospital physicians) with the corresponding limitations for invasive measures. We should not forget that in the German EMS system the application of a chest tube is a very rare procedure[16] and therefore should be applied only by those out-of-hospital physicians who have obtained the appropriate competence.

In the Resuscitation Guidelines 2015 of the European Resuscitation Council, the needle decompression is equally fast, but suggested as a "success-limited" method.[17] In line with the literature, the needle length is stated as a main problem.[18] It was only possible to demonstrate a success rate of 66% to 81% of decompression with a needle length of only 5 cm. They recommended, as well as PHTLS, a needle length of 8 cm.[18] Currently, these long needles for adequate decompression are often missing in the EMS equipment.

The topic of fluid resuscitation generally results in the most divergent recommendations of the S3 Guideline and PHTLS in the presented comparison.

The S3 Guideline recommends Ringer's malate, or alternatively Ringer's acetate or lactated Ringer's solution (GoR B). Lactated Ringer's solution is also recommended by PHTLS, but PHTLS still mentions the normal saline, which has led to the rating "major variation," as, according to the S3 Guideline, isotonic saline solution should not be used. Lactated Ringer's solution remains the resuscitation crystalloid of choice in the United States today, although it is recommended to minimize the amount of crystalloid administered. Even the use of lactated Ringer's solution needs to be put into question, since superior alternatives such as Ringer's malate and Ringer's acetate are approved here.[19]

Concerning the use of colloidal solutions in hypotensive trauma patients, the S3 Guideline prefers hydroxyethyl starch 130/0.4, whereas PHTLS tends to recommend against colloid solutions, which results in a "major variation." Both statements address closely related issues; however, the statements do not fit in the way that they could directly be compared for congruence.

Europeans prefer colloids because we believe they have more pronounced effects on acute restoration of blood pressure than crystalloids. From the viewpoint of evidence-based medicine, so far neither the conclusion "recommended" nor "not recommended" is justified. This noninferiority of colloids on long-term outcome justifies a GoR 0 (may be used) by the German volume replacement guideline.[19]

Statements to the use of hypertonic solutions were also classified as major variation (Table 4). Hypertonic saline can quickly restore blood pressure in patients with multiple traumas; however, improved long-term survival was not demonstrated. This noninferiority on long-term outcome of hypertonic solutions justifies a GoR 0 (may be used) by the German S3 Guideline. Missing approval of the US Food and Drug Administration (FDA) that may be driven by a vast variety of causes aside from effects of the drug itself is irrelevant for patient treatment in Europe.

Prehospital Trauma Life Support did not take relevant data pointing to benefits of hypertonic solutions in penetrating trauma into account, which led to the German GoR B recommendation.[20] Again, missing FDA approval that may be driven by a vast variety of causes aside from effects of the drug itself is irrelevant for patient treatment in Europe.

Hypertonic saline can quickly restore blood pressure in multiple traumas; however, improved long-term survival was not demonstrated by its use in patients with severe traumatic brain injury.[21] This noninferiority on long-term outcome of hypertonic solutions justifies a GoR 0 (may be used) by the German S3 Guideline. In contrast, referring to one study,[21] PHTLS states "not recommended" for hypertonic saline.

Pain management is mentioned in the S3 Guideline just as "transport should be as gentle as possible and free of pain." Analgesia is an important part of emergency treatment[22] and has to be performed as early as possible during the EMS therapy.[23] Over many decades, in Germany, analgesia was carried out by out-of-hospital physicians, which represents a considerable difference to other non–physician-based EMS systems. In recent years, however, analgesia with opioids or ketamine is slowly becoming routine practice by German paramedics.[24,25] Regardless of which group it is applied, analgesia is considered to be one of the main pillars in the German out-of-hospital EMS community. The recommendations in the PHTLS manual compared with the S3 Guideline are only a minor variation, as the analgesia is considered nuanced and not generally recommended. Their focus is on patients with isolated limb injury or spinal fracture, particularly if prolonged transport occurs and therefore should be avoided in patients with ventilation disorder or shock. This may be due to the different executing professionals but allows the adaptation of the analgesia to the local circumstances.

As in the European setting, with a short rescue time of less than 60 minutes, a bladder catheterization is not useful and furthermore not necessary.[26,27] Because of the multiple-injury patterns in this kind of patient, pelvic or intra-abdominal injuries have to be suspected frequently. In this case, a urethral injury cannot be excluded in the out-of-hospital setting. Again, the PHTLS concept is a worldwide concept, and for this reason, a catheterization might be useful in order to monitor the diuresis during a long transport period in other areas of the world.

A limitation of this study is the subjective rating of the experts. Especially the first round of the expert rating has not

shown a strong consensus, because of different apprehension of the experts. Thus, for all differences in the expert rating, a consensus was found in the Delphi method. This finally showed that there are no clinical significant differences in treatments, except for specific infusion therapy and narcotics.

According to our comparison, the PHTLS manual is largely compatible with the German S3 Guideline from 2011, with 88% of recommendations being equal or having only a minor variation. The 12% divergent statements mainly concern fluid resuscitation, which should be the subject of further research. Minor deviations could be explained by different addressees: the S3 Guideline is a national guideline for the German emergency medical service with emergency physicians. Prehospital Trauma Life Support is a concept for various emergency medical service systems all over the world. All in all, there is a high conformity.

AUTHORSHIP

D.H. and M.M. conceived the study and compared the recommendations. D.H. drafted the methods and the rating system and managed data. D.H., M.B., A.R.H., U.S., and M.M. performed the data analysis. D.H. and M.M. drafted the manuscript. L.S. and B.G. performed textual analysis and supervised the analysis. All authors contributed substantially to its revision.

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DISCLOSURE

D.H., L.S., A.H., B.G., and M.M. are PHTLS instructors and receive instructor fees. M.B. was involved as an author and as a representative of the German Society of Anesthesiology and Intensive Care Medicine in the development process of the German S3 Guideline on Treatment of Patients With Severe and Multiple Injuries. D.H. was involved as an author and as a representative of the German Association of Paramedics in the development process of the German S3 Guideline on Treatment of Patients With Severe and Multiple Injuries.

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2.4 Dokumentationsqualität als Surrogat-Parameter für Aufmerksamkeit und Trainingseffektivität

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RESEARCH ARTICLE

Quality of Documentation as a Surrogate Marker for Awareness and Training Effectiveness of PHTLS-Courses. Part of the Prospective Longitudinal Mixed-Methods EPPTC-Trial

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Abstract

Objective

Care for severely injured patients requires multidisciplinary teamwork. A decrease in the number of accident victims ultimately affects the routine and skills. PHTLS ("Pre-Hospital Trauma Life Support") courses are established two-day courses for medical and non-medical rescue service personnel, aimed at improving the pre-hospital care of trauma patients worldwide. The study aims the examination of the quality of documentation before and after PHTLS courses as a surrogate endpoint of training effectiveness and awareness.

Methods

This was a prospective pre-post intervention trial and was part of the mixed-method longitudinal EPPTC (Effect of Paramedic Training on Pre-Hospital Trauma Care) study, evaluating subjective and objective changes among participants and real patient care, as a result of PHTLS courses. The courses provide an overview of the SAMPLE approach for interrogation of anamnestic information, which is believed to be responsible for patient safety as relevant, among others, "Allergies," "Medication," and "Patient History" (AMP). The focus of the course is not the documentation.

Results

In total, 320 protocols were analyzed before and after the training. The PHTLS course led to a significant increase ($p < 0.001$) in the "AMP" information in the documentation. The

manuscript. There was no additional external funding received for this study. This does not alter our adherence to PLOS ONE policies on sharing data and materials.

Competing Interests: BG, CW, DH, MM, MD are PHTLS instructors. Author BG received funding in the form of salary from Megamed Emergency Management GbR, a commercial company. This company offers different trainings for health care personnel. Megamed does not offer PHTLS-courses and has not funded or supported our trial in any way. Mr. Gliwitzky is not paid by Megamed to take part at this trial. The funders have no influence on study design, data collection and analysis, decision to publish, or preparation of the manuscript. This does not alter the authors' adherence to PLOS ONE policies on sharing data and materials.

subgroups analysis of "allergies" (+47.2%), "drugs" (+38.1%), and "medical history" (+27.8%) before and after the PHTLS course showed a significant increase in the information content.

Conclusion

In summary, we showed that PHTLS training improves documentation quality, which we used as a surrogate endpoint for learning effectiveness and awareness. In this regard, we demonstrated that participants use certain parts of training in real life, thereby suggesting that the learning methods of PHTLS training are effective. These results, however, do not indicate whether patient care has changed.

Introduction

Accidents have the most common cause of death since the middle ages [1]. In Germany, 4.7 deaths per 100,000 inhabitants have been reported, and in the United States (US), 11.4 per 100,000 inhabitants [2]. The peak age is between 18 to 25 years [3]. These young employed people particularly benefit from rapid rehabilitation after an accident. In Germany alone, the economic costs of traffic accidents amount to 31 billion euros [4].

Fortunately, there is a continuous decrease in the number of accidents [5,6]. The proportion of injured patients, based on the sum of all emergency patients in Germany, is approximately 10% [7]. The decreasing number of accident-related emergency calls destabilizes the routine [8]. This underlines the importance of effective training in emergency medicine.

In the 1970s, the treatment of trauma patients in the emergency room became increasingly standardized, following the introduction of Advanced Trauma Life Support (ATLS), which provided a new structure in the care for severely injured patients [9]. The associated pre-hospital care equivalent to ATLS is the Pre-Hospital Trauma Life Support (PHTLS) concept. There are also other training concepts, but PHTLS is an established concept in 66 countries around the world. Induction into PHTLS is delivered through two-day courses for medical providers, with the aim of improving the pre-hospital care of trauma patients.

In the late 1990s, Ali et al. showed that, in less developed emergency medical services (EMS) systems, PHTLS improves skills and procedures [10] and leads to a significant reduction of mortality [11,12]. However, these results cannot be transferred to current and developed EMS systems. A Scandinavian observational study showed that PHTLS training is associated with a small reduction in mortality (the mortality risk was 4.7% (36/763) without PHTLS training and 4.5% (94/2067) with PHTLS training) [13]. In a subgroup analysis of motor-vehicle traffic injuries, no reduction of mortality was observed [14]. It is questionable if the end-point "mortality" is sufficient to evaluate the effects of PHTLS in modern emergency care.

Importance

In EMS-district Wiesbaden (Germany), a previously used training concept has been revised due to the lack of learning success and employee satisfaction. At the instigation of the medical director, PHTLS courses were mandatorily established for all paramedics in EMS-district Wiesbaden [15].

Against the background of a large EMS district introducing PHTLS as standard training, with mortality as an endpoint having demonstrated little advantage of PHTLS in previous

studies, the goal of this project was to analyze subjective and objective changes among participants and in real patient care, as a result of PHTLS courses.

Goals of this investigation

The aim of the study was to investigate documentation quality before and after PHTLS courses, as a surrogate marker of training effectiveness and awareness.

Materials and Methods

Study design

This was a prospective pre-post intervention trial and was part of the mixed-methods longitudinal EPPTC (Effect of Paramedic Training on Pre-Hospital Trauma Care) study, evaluating the subjective and objective changes in participants and real patient care, as a result of PHTLS courses. The complete study is described in the previously published study protocol [16].

Research ethics approval

The Ethics Committee of the Medical Faculty of the Eberhard Karls University of Tuebingen and the University Hospital approved the study proposal, number 197/ 2013BO2, on May 24, 2013. The study is registered in the German Clinical Trials Register as ID, DRKS00004713. Data collection, coding, routing, and analysis were coordinated by a data protection officer at the University of Tuebingen and the University Hospital of Tuebingen. In another part of the project, participants were surveyed through a questionnaire, after providing written consent. For this part of the study, no personal information from participants or patients was collected.

Study setting and selection of participants

The study was performed in the EMS in Wiesbaden (Germany). The operational district in Wiesbaden has five commissioned EMS agencies (four charities, one private provider). The EMS in Wiesbaden had 375 paramedics and served 462,098 inhabitants during the study period of 2013/2014.

In the context of various difficulties and problems, the controlling authority committed all paramedics to attend PHTLS courses, so as to establish uniform structures and principles [15].

Intervention

PHTLS courses are well-established worldwide, comprising two-day courses for paramedics and emergency physicians, with the aim being to improve pre-hospital care for trauma patients. PHTLS courses are characterized by a large variety of teaching methods (e.g., lectures, practical case studies, and skills training), with a low instructor—participant ratio (1:4), many practical activities, and continuous interaction. In addition to various skills, the priority-based structure, ABCDE (Airway, Breathing, Circulation, Disability and Exposure), is taught and practiced in scenario-based training sessions. The teaching of PHTLS conforms with a high conformity to the key recommendations of the German "Guideline on Treatment of Patients with Severe and Multiple Injuries" [17].

"ABCDE" represents the core strategy and has the highest attention during the course. With regard to the awareness and transfer of teaching content to the real working world, a surrogate parameter, which was not so focused in the courses, seemed more appropriate. As part of the so-called "secondary assessment," PHTLS courses, as well as other courses like ATLS and AMLS, use "SAMPLE" as a mnemonic tool [18]. The letters "AMP" are an abbreviation for allergies, medication and patient history (pre-existing illness). The analysis reviewed these

Table 1. Main groups and number of report categories.

Main groups	Number of report categories
Reanimation	2
Surgical emergencies	46
Internal emergencies	60
Neurological emergencies	18
Pediatric emergencies	8
Gynecological emergencies	12
Other emergencies	22

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items in the standardized EMS protocols from actual field operations performed by paramedics. The focus of the lesson was not set on the operation documentation. The decision to focus on "AMP" has different reasons. The first is its importance for patient safety [19]. The other reason came up during the initial data analysis, which showed that data processing of "L" and "E" was bugged. To retain data quality, just "AMP" was included.

The state of Hessen used so-called report categories ("RMZ"), in which medical indications (e.g. combustion, hyperventilation) were reported. The main groups are shown in Table 1. To indicate the patient's condition, an emergency severity score ("RMC") and timestamps were used (Table 2). The minimum number of points assigned as the RMC is six; the maximum number of points is 42. Deviations from the physiological condition of the patient are indicated by RMC > 6. There was no validation of correct assessment or use by the paramedics or emergency physicians.

Data collection and processing

The EMS protocols were required in the context of each EMS field operation and archived at the EMS agencies, in concordance with the local EMS regulations and supervisory authority. We collected the first protocols the year before and after the courses; the inclusion criteria were all operations without emergency physicians and RMC > 6. Because the highest impact is given when participants use SAMPLE for all emergency patients, we included all kind of emergencies, not only trauma patients.

Outcome measures

The primary outcome measure was a change in the quality of documentation, as a surrogate endpoint for training effectiveness and awareness. Secondary outcome measures were

Table 2. Emergency severity score (RMC): Emergency severity is mapped through a six-digit number (RMC). Each digit reflects the patient's condition (at first contact) in relation to the characteristics of consciousness, respiration, circulation, injury, neurological condition, and pain again. The minimum value of "1" means "inconspicuous," in reference to each characteristic; the maximum value of "5" refers to an extremely severe degree of the relevant impairment.

Classification	Consciousness	Respiration	Circulation	Injury	Neurology	Pain
1	Normal	Without	Without	None	Without	None
2	Somnolent	Slightly abnormal	Slightly abnormal	Slight	Previously known disorder	Slight 3
3	Potential loss of consciousness	Potentially	Threatening severe disorder	Conceivable	Threatening disorder	Moderate 4–6
4	Comatose I–III	Severe disorder	Severe disorder	Severe	Acute disorder	Strong7–9
5	Comatose IV	Apnea	Pulseless	Multi-system trauma	Progressive Disorder	Extreme 10

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subgroup analyses for differences between the documentation items in the main diagnosis groups (based on the report digits) and the group of patients in severe conditions (based on the emergency severity score).

Primary data analysis

The sample size of 320 cases per group (pre; post) was based on a detectable difference of 15, with a power of 80%. Type I error was probably 0.05.

The protocols were selected for participating EMS agencies, proportional to their level of participation in the total operations protocols.

The documentation items were offset by one point for each completed item. With a total of three available documentation items (AMP), 0–3 points per protocol were possible, the total of which was obtained for the pre- and post- groups. In each group, a minimum of 0 points and a maximum of 960 points (3 × 320 protocols) were possible.

Statistical analysis

Formal pre- and post-intervention statistical evaluation was performed with Mann-Whitney's *U* test for continuous variables and Fisher's Exact Test for categorical variables. A two-tailed test, with $p < 0.05$ was considered statistically significant. All data were analyzed using the statistical software, SPSS (Version 23.0, IBM Inc., Armonk, NY, USA). For continuous variables, data are shown as mean ± standard deviation. For categorical variables, percentages are presented.

Results

In total, 640 protocols (320 for each year) were included in the study. The two most common indications were surgical (n = 308, 48.1%) and internal (n = 197, 30.8%) emergencies (Fig 1).

The mean (with standard deviation) of the RMC (emergency severity score) was 8±2 in both years; the median prior to training was 9, and 8, after training. Fig 2 shows an overall right-skewed distribution, with 1.42.

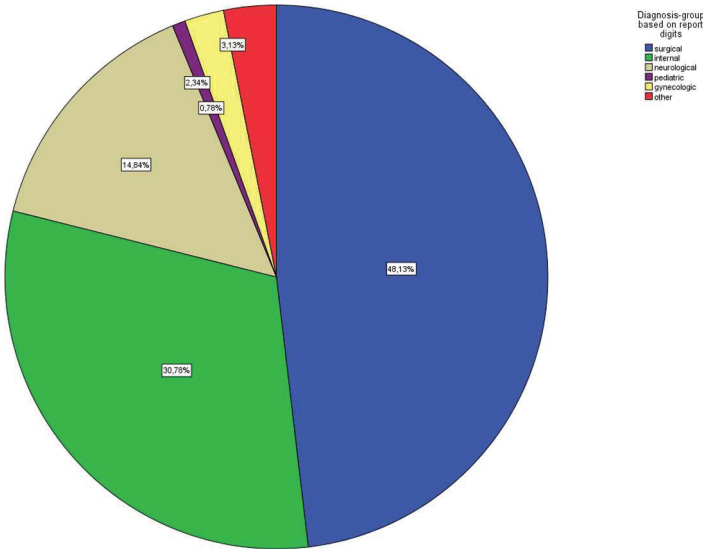

Fig 1. Overall range indications of the selected emergency operations.

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The totals of the documentation items (AMP) were n = 364 points in the pre-course group and n = 726 points in the post-course group ($p < 0.001$), which made up an overall increase of 37.7% (Fig 3).

The shifts in the subgroups' allergy, medication, and patient history were also significant ($p < 0.001$), as shown in Table 3.

According to the indications of operations, a subgroup analysis of surgical and internal indications, and all the other indications in one group, as well as a different point of view on operations with RMC > 9, also showed a significant increase in documentation values (Fig 4).

Discussion

In this trial, we used the quality of documentation as a surrogate endpoint for the training effectiveness of PHTLS courses in 640 operations protocols. Our score, related to the three items, allergy, medication, and patient history, showed a significant increase of 37.7% after the courses. Based on the emergency severity score or "RMC," Fig 2 shows that most of the patients were not severely injured or sick. The subgroup analysis of the operation protocols of most severely injured or sick patients, respectively, with RMC > 9, confirmed the increase by a significant +44.8%. The individual documentation items also increased by 27.8% for *patient history*, 38.1% for *medication*, and a notable 47.2% for *allergy*.

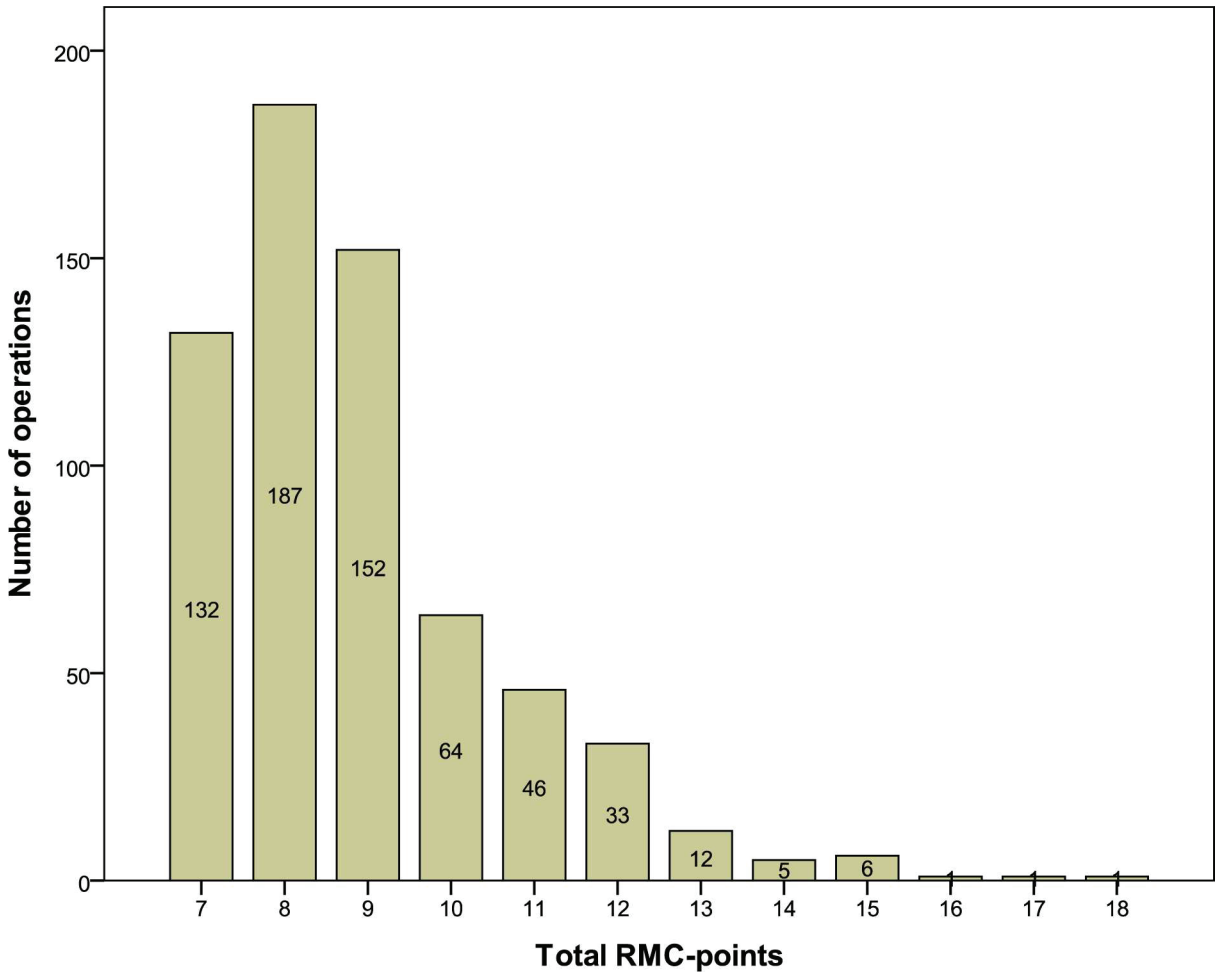

Fig 2. Total number of RMC-points and number of operations.

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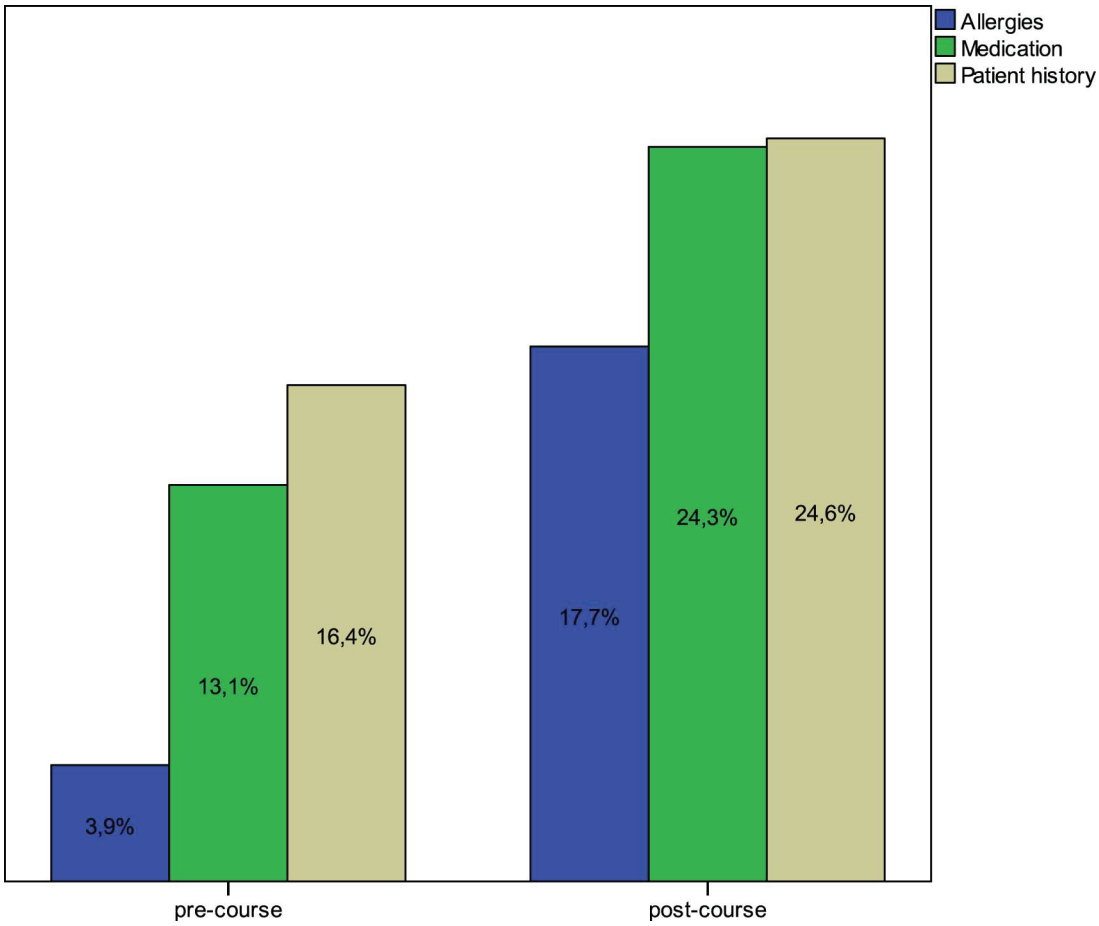

Fig 3. Total "AMP" points were 364 points in the pre-course group and 726 points in the post-course group ($p < 0.001$).

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Considering the subgroups' surgical and internal indications, it seems that the largest increase among both groups was the 42.1% observed in the surgical group. Improvement was also observed in the internal group (34.7%). The baseline value of the fulfilled "AMP"-information was 41.1% in the internal group and 32.3% in the trauma group. Based on the relative proportions of the indications, it is arguable as to whether trauma training is responsible for the larger increase in the trauma group or if for example discussion about new anticoagulation [20–22] increased documentation.

RMC (emergency severity score) was 8±2 in both years, this shows that patients in our investigation were not seriously ill or injured. This maybe represents a typical patient collective for a large city. The extent to which our results can be transferred to the stressful emergency care of seriously injured patients is unclear.

Table 3. A comparison of allergy, medication, and patient history before and after the PHTLS course.

	Pre-course	Post-course	Difference	p-value
Allergy	42	193	+47.2%	<0.001
Medication	143	265	+38.1%	<0.001
Patient history	179	268	+27.8%	<0.001

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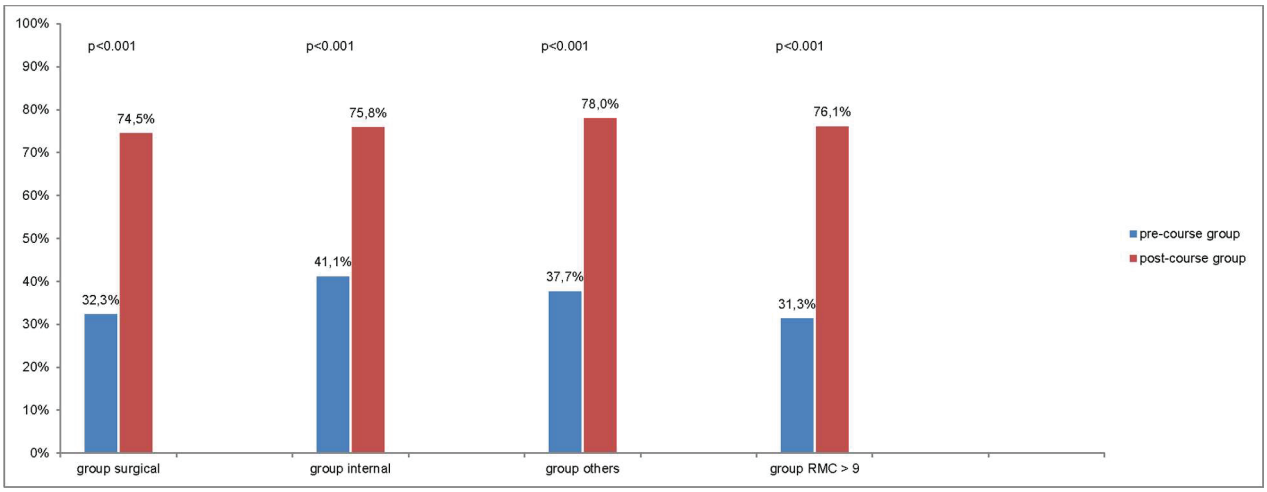

Fig 4. Subgroup analysis of the indication groups, including surgical, internal, and all other indications, as well as operations with RMC- > 9, showed an increase in documentation values ($p < 0.001$).

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Overall, the quality of documentation increased significantly, leading to the notion that PHTLS courses influence participants, with remarkable effects on real patient care and documentation.

Despite the increase in the quality of documentation, documentation still needs to be improved in 24.4% of the cases, even after the courses.

The loss of relevant medical information (e.g., during handovers) is a known problem that concerns not only documentation, but also verbal handovers [23]. This particularly affects the collection of medical history and physical examination results [24]. A video-based error analysis, as conducted by Bergrath et al., of documentation by physicians, following simulation, showed that 20% of the information was missing and 22% of the documented information was incorrect [25].

It has been shown that training or tutorials on documentation improve the quality of documentation [26–28] by 12.5% to 51%. In contrast to cited studies, in which improvement in documentation was considered an endpoint, in our trial, secondary assessment with queries on allergies, medication, and patient history, based on the learned SAMPLE schema, was only a secondary aspect, preceded by use of documentation. Nonetheless, our investigation showed an overall increase in documentation quality by 37.7%, which we think is remarkable.

It could already be demonstrated that the use of protocols, which have integrated memory aids, significantly reduce documentation errors [29]. In the present study, however, the operation protocols had memory aids, such that analyzed items had to be documented in a free-text field.

The results also indicate that, as already known [30], obvious educational interventions may generally have an impact on the system or students. This is due to not only improvement in the documentation for trauma and surgical patients, respectively, but for all other operations, too. Despite the internal medicine group's initial documentation, which was already better, at 41%, compared to the surgical group, at 32%, an increase on 75.8% was also noted.

This result may also be explained by increased awareness regarding the three items "AMP". Such increased awareness can be seen partly through simple educational interventions aimed at the public, in relation to stroke detection [31].

For healthcare professionals, awareness is one of the main elements of non-technical skills and a characteristic of high-performing teams [32]. The results of the present study show that awareness can be instilled via training, without much effort. Often, the amount of information

in a given (emergency) situation causes an information overload, because the information is not adequately prioritized and categorized [33]. The taught SAMPLE scheme seems to bring some order, in this regard.

This trial, like many others in medical and complementary disciplines, uses surrogate endpoints, which have no value of their own [34–39]. They simply constitute indirect evidence for training effectiveness in this study. Therefore we decided not to use the ABCDE, because this was highlighted in the PHTLS trainings. Also, documentation of ABCDE is quite more difficult. In the care for less injured patients with no ABCDE problem, the need of documentation of the absence of a problem is forgotten easily. For example a patient with extremity injury without analgesia has not a worse treatment, without documentation of the uncompromised airway and breathing. The need of documentation of the SAMPLE information is more obvious—even if negative, for instance "no allergies" or "no medication". On the other hand "SAMPLE" was just slightly taught in one lesson, but is important for every patient. So the transfer of this into real patient documentation shows the big effects of one training on awareness and the learning process.

An alternative validation could have been the use of a written exam to evaluate training effectiveness, similar to Ali et al., in 1998, who showed good learning success among PHTLS-course students [40], using a pre-/post-test. However, the aim of our study was to investigate changes in real patient care, as a result of the courses, which would not have been possible with a written exam. This led to the decision to use the documentation quality of real emergency operations as surrogate endpoints for training effectiveness.

The study participants were informed about the study and consented to scientific evaluation. Therefore, a Hawthorne effect [41] could be assumed and was critically discussed. As it had not been announced that the documentation would be evaluated, in our opinion, the Hawthorne effect is not applicable, in this instance.

Due to the high volume of EMS operations, the predetermined sample size of operation protocols was reached within a short period of time, even though the same month was chosen each year to collect protocols.

A follow-up for this part of the trial could not be initiated because subsequent training could falsify the result. Therefore, the continuous quality of documentation, variance thereof, and long-term training effectiveness cannot be verified. These effects could perhaps be improved through refresher training, which was not evaluated in the present study.

Conclusion

In summary, we showed that PHTLS training improves the quality of documentation, which we used as a surrogate endpoint for learning effectiveness and awareness. In this regard, we demonstrated that participants use certain parts of training in real life, thereby suggesting that the learning methods of PHTLS training are effective. However, these results do not indicate as to whether patient care has changed.

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Writing – original draft: DH MM SB MH.

Writing – review & editing: DH SB MH RL BG CW PG US MD MM.

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2.5 Subjektive Sicherheit, Selbstvertrauen und Lernverhalten

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Subjective safety and self-confidence in prehospital trauma care and learning progress after trauma-courses: part of the prospective longitudinal mixed-methods EPPTC-trial

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Abstract

Background: Prehospital trauma care is stressful and requires multi-professional teamwork. A decrease in the number of accident victims ultimately affects the routine and skills and underlines the importance of effective training. Standardized courses, like PHTLS, are established for health care professionals to improve the prehospital care of trauma patients. The aim of the study was to investigate the subjective safety in prehospital trauma care and learning progress by paramedics in a longitudinal analysis.

Methods: This was a prospective intervention trial and part of the mixed-method longitudinal EPPTC-trial, evaluating subjective and objective changes among participants and real patient care as a result of PHTLS courses. Participants were evaluated with pre/post questionnaires as well as one year after the course.

Results: We included 236 datasets. In the pre/post comparison, an increased performance could be observed in nearly all cases. The result shows that the expectations of the participants of the course were fully met even after one year ($p = 0.002$). The subjective safety in trauma care is significantly better even one year after the course ($p < 0.001$). Regression analysis showed that (ABCDE)-structure is decisive ($p = 0.036$) as well as safety in rare and common skills (both $p < 0.001$). Most skills are also rated better after one year. Knowledge and specific safety are assessed as worse after one year.

Conclusion: The courses meet the expectations of the participants and increase the subjective safety in the prehospital care of trauma patients. ABCDE-structure and safety in skills are crucial. In the short term, both safety in skills and knowledge can be increased, but the courses do not have the power to maintain knowledge and specific subjective safety issues over a year.

Trial registration: German Clinical Trials Register, ID DRKS00004713, registered 14. February 2014

Keywords: Safety, Allied health personnel, Trauma care, Competence, Learning progress, Self-confidence, Skill, Structure

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Background

Emergency care professionals are faced with stressful and complex situations in prehospital care of seriously injured patients [1–3]. Especially in sophisticated, complex and possible rare situations, stress can be detected with multiple stress measurements by heart rate and salivary cortisol measurements as well as workflow analysis, both in reality and in simulation training [1, 3]. Moorthy et al. showed in surgical settings that stress causes more skill and knowledge-based errors [4]. However, in medical simulation training, it was demonstrated - by means of salivary alpha-amylase analysis - that training caused similar stress to real clinical situations. On the other hand, stress was reduced in the post-test and performance was improved [5].

Today, lower incidence of severely injured trauma patients, therefore decreased routine and considerable stress on health care providers underline the importance of effective training in emergency medicine [6].

In the 1970s the treatment of trauma patients in the emergency room became more standardized by the introduction of Advanced Trauma Life Support (ATLS), which provided a new structure in the care for severely injured patients [7]. An associated prehospital equivalent to ATLS is the Pre-Hospital Trauma Life Support (PHTLS) concept. PHTLS is a worldwide established concept with two-day courses for medical providers with the aim to improve the prehospital care of trauma patients.

In the Emergency Medical Service (EMS)-district Wiesbaden (Germany) a previous training concept has been revised due to lack of learning success and satisfaction of participants. At the instigation of the medical director, PHTLS courses were mandatorily established for all paramedics in the EMS Wiesbaden [8].

Goals of this investigation

Under the circumstances that a large EMS- district introduces this standard training, the goal of this study is to investigate the subjective safety in prehospital trauma care and learning progress by paramedics in a longitudinal analysis. Special attention is given to the longitudinal safety and assessment, not on a short-term increase.

Methods

Study design

This was a prospective pre-post intervention trial and was part of the mix-method longitudinal EPPTC (Effect of Paramedic Training on Prehospital Trauma Care)-study evaluating the subjective and objective changes in participants and real patient care through the courses. The complete study is described in the previously published study protocol [9].

Study setting and selection of participants

The study was performed in the EMS in Wiesbaden (Germany). The operational district in Wiesbaden has five commissioned EMS agencies (four charities, one private provider).

In the context of various difficulties and problems, the controlling authority committed all paramedics to attend the PHTLS courses to create uniform structures and principles [8].

Intervention

The two-day PHTLS courses are a worldwide standard for paramedics and emergency physicians with the aim to improve prehospital care for trauma patients. PHTLS courses are characterized by a large variety in the teaching methods (e.g. lectures, practical case studies, skill training), with a close instructor-participant ratio (1:4), many practice activities and continuous interaction. In addition to various skills, the priority-based structure ABCDE (Airway, Breathing, Circulation, Disability and Exposure), is taught and practiced in scenario-based training sessions. Teachings correspond with the key recommendations of the German Guideline on Treatment of Patients with Severe and Multiple Injuries [10].

Data collection and processing

The course participants were interviewed with a questionnaire concerning their level of knowledge, skills and safety in prehospital trauma care. This data was collected at three time points: at the beginning of the course (before the first lesson: t0 “pre”), at the end of the course (before the course-results were presented: t1 “post”) and as well as one year after the course (t2 “after”). The circumstances of the data collection were identical. The questionnaires were pseudonymized with a four-digit code to represent the relationship between the different times.

Questionnaire development

The questionnaires were developed by an interdisciplinary team consisting of medical educators, emergency physicians, sociologists and psychologists. The questionnaire development was based on unstructured literature research and focus groups interviews of participants from previous courses, as well as on the experience of the expert panel.

Questions should include the subjective safety in skills, but also knowledge and decision making. Moreover, the question was how satisfied the participants were with the training program.

We used single-item scales in the questionnaire, which were constructed based on practical experience and the envisaged training. For that we used numerical endpoint named scales with a 7-point likert scale to avoid ceiling or floor effects [11]. The range of the scales for participants was from −3 (strongly disagree) to +3 (totally agree),

including 0. For statistical calculation, we transformed the scale to 1 to 7.

The core set of questions to evaluate the intervention was asked at three time points. Additionally, there are some questions which were asked only for the first-time point t0 and questions which were asked only after a year.

Primary data analysis

The sample size calculation for the questionnaires with a power of 85% for an effect size d = 0.2 resulted in 238 needed questionnaires in each group. A two-tailed p-value <0.05 was considered statistically significant. As data was not normally distributed and because of loss to follow-up, we added 10%, finally n = 262 questionnaires per group.

Statistical analysis

We assessed the construct validity by means of exploratory factor analysis: Bartlett's test of sphericity and the Kaiser-Meyer-Olkin measure of sampling adequacy were used to check for the appropriateness of the factor analysis. We ran a principal component analysis (PCA) with varimax rotation. Eigenvalues greater than 1.0 were required to retain component factors, and factor loadings of 0.5 or greater were considered satisfactory for the interpretation of the factor structure.

Internal consistency reliability was determined using Cronbach's alpha coefficient. Values ≥0.70 are acceptable [12].

Because data was not normally distributed the Wilcoxon signed-rank test was used for paired continuous variables and the χ^2-Test or fisher's exact test for categorical variables. A two-tailed p-value <0.05 was considered statistically significant. For correlations with ordinal-scaled data, Spearman's rank correlation coefficient was calculated. A linear regression was performed to identify predictors with relevant impact on the main question. Durbin-Watson was checked for autocorrelation of the predictors, and the residuals for normal distribution. Regression coefficients are given with standard error and the respective p-value of the model. All data was analysed using the statistical software SPSS (Version 24.0, IBM Inc., Armonk, NY, USA). For continuous variables, data is shown as mean ± standard deviation, as well as median. For categorical variables, percentages are presented.

Results

In principle, we received 312 questionnaire sets. Overall 55 cases were excluded because of a missing time point t2. We started with 236 sets and performed a separate non-responder analysis. Between the intervention and the follow up 21 students had further trauma training, so they were excluded as well.

Students characteristics

Demographic characteristics of the surveyed participants is shown in Table 1. The age of the participants and the professional experience correlate as expected (r = 0.84, p < 0.001).

Non-responder analysis

The non-responder (n = 55, 17.6%) implied less women than the responder (21.8% versus 36.7%, p = 0.041). Both the mean age (35.8 versus 36.1 years, p = 0.852) and the professional experience (p = 0.985) showed no differences between the two groups. To see if non-responder were particularly dissatisfied with the course, the item "my expectations for the course have been met" was tested for both groups. The mean for the non-responders was 5.0 points and for responders 6.25 points (p = 0.180).

Principal component analysis

The Kaiser-Meyer-Olkin analysis yielded an index of 0.847, and Bartlett's test of sphericity gave χ^2 = 1798.262 (p < 0.0001); these indicate the appropriateness of the data for PCA. Four factors with eigenvalues ≥1.0 were extracted by PCA and accounted for 64.1% of the overall variance. As shown in Table 2, the first factor (denoted as expectations) accounted for 30.6% of the total variance, and it included 5 items with factor loadings between 0.62–0.89. The second factor (common procedures) accounted for 19.6% of the variance with factor loadings between 0.53–0.81. The third factor (preparation and literary usage) accounted for 7.3% of the variance, comprised just two items with factor loadings 0.66–0.79.

Table 1 Demographic characteristics of the students

	n	%
Age, years		
mean + SD	36.1 ± 10.2	
Min	20	
Max	63	
not reported	n = 27	
Sex		
Male	146	61.9
not reported	5	2.3
Professional experience, years		
0–2	44	18.5
3–4	22	9.4
5–6	20	8.3
7–8	18	7.5
9–10	18	7.5
11–12	17	7.1
13–14	22	9.4
≥ 15	76	32.3

Table 2 Factors with description

Factors	Description	Number of items	Cronbach's alpha	Item means
Factor 1	expectations	5	0.885	6.05
Factor 2	common procedures	5	0.837	5.15
Factor 3	preparation, literature	2	0.672	5.12
Factor 4	rare procedures	3	0.601	3.75

The fourth factor (rare procedures) accounted for 6.6% of the variance with factor loadings between 0.55–0.87. The factor loading of one question was only 0.45 and could not be assigned to one of the four factors. The naming of the factors was determined by the factual context and literature [13, 14].

Expectation and preparation

Expectations are presented in accordance with the factor analysis as shown in Table 3. Based on the median, four items were evaluated consistently in factor 1 equal by 6.0.

The last item "I expect/could to expand my knowledge in trauma care." got the highest expectation value with median 7.0, which was fulfilled in the post measurement with median 7.0. After one year, the value fell on median 6.0.

Apart from the median, mean values showed a partly significant increase from t0 to t1. After a year, when comparing t1 to t2, a significant fall could be seen. In comparison of t0 to t2, all items decreased significantly, except for the expectations for the course, which had exceeded in post values ($p < 0.001$) and also after one year ($p = 0.002$).

Factor 3 "Literature and course preparation" included the item "I am anxious regularly to do further studies by medical journals." and was evaluated just before the course (mean 5.3 ± 1.1). The item "By the course manual I feel well prepared/has prepared me well for the course" was evaluated at all three time points. Time point t0 was 4.9 ± 1.3, t1 was 5.2 ± 1.2 and t2 4.9 ± 1.4. The difference between before the course to one year after is not significant ($p = 0.95$). The difference from before the course to directly after the course is significant ($p = 0.012$). The rating of t1 to t2 is also significant ($p = 0.014$).

Common procedures

Common procedures are also shown in Table 3. Handling neck collars and removing helmets are the only skills that don't drop significantly from t1 to t2. All common procedures are significantly better rated after one year, with exception of the extrication procedure. One of the most important requests to the course is the safety in the treatment of trauma care. This was assessed by the participants as significantly better after the course, even after a year ($p = 0.001$).

Rare procedures

The thoracic needle decompression was obviously the skill with the least safety and suspected routine of all skills before the course. Even here the classification after one year was significantly better than prior to the course; nonetheless, Table 3 shows the biggest changes. The pelvic sling offered the largest learning effect directly after the course and was assessed as the spine board to be significantly safer in handling even one year after than before the course.

Additional questions

Additional questions are shown in Additional file 1. If the single item "I attend the kinematics more than before the course" (5.4 ± 1.4) is divided in two groups by its median (≥6), one year after the course (t2), it shows that provider who pay more attention to kinematics are safer in the assessment if it ($p < 0.001$).

Providers who tend to use the ABCDE structure for patient assessment (item "I use the ABCDE structure in the care of trauma patients", 6.0 ± 1.2) divided by is median (≥6)) stated that they are better in classification of critical or non-critical patients ($p < 0.001$). Also, the calculation of the use of the ABCDE-structure and safety to treat life-threatening situations faster, shows a moderate correlation $r = 0.598$, $p < 0.001$.

The willingness to learn or for further education, measured by the participation in other courses, is equally distributed throughout all ages ($p = 0.35$). Participants who have attended additional courses, stated that they frequently educate themselves by reading journals etc. ($p = 0.095$).

The regression analysis showed that subjective safety in treatment of traumatological emergencies after one year was significantly influenced using the ABCDE-structure for patient assessment ($p = 0.036$), and as a surrogate marker for common skills the handling neck collars ($p < 0.001$) and for rare skills the thoracic needle decompression ($p < 0.001$), as shown in Table 4.

Discussion

The aim of prehospital trauma courses is to gain the assurance in the traumatological skills by improving the knowledge of trauma care, to be able to act faster in life-threatening situations. Cognitive knowledge, technical skills and clinical judgment are the main pillars for healthcare providers [15]. The EPPTC-Trial investigates the impact of such courses and has shown that the trainings improve documentation quality, which was used as a surrogate endpoint for learning effectiveness and awareness [16]. It was demonstrated that participants used certain parts of training in real patient care, thereby suggested that the learning methods of prehospital trauma training are

Table 3 Results

	QUESTION	TIME POINTS			DIFFERENCES		
		pre t0 MW ± SDmedian	post t1 MW ± SDmedian	after t2 MW ± SDmedian	t0-t2 *p*-value	t0-t1 *p*-value	t1-t2 *p*-value
EXPECTAITONS	1. I have high expectations for the course/my expectations have been fulfilled.	5.6 ± 1.2 6.0	6.2 ± 0.9 6.0	5.9 ± 1.1 6.0	0.002	<0.001	<0.001
	2. I expect/have an increased safety in the assessment of the kinematics.	5.9 ± 1.1 6.0	6.1 ± 1.0 6.0	5.6 ± 1.3 6.0	0.009	0.190	<0.001
	3. I expect/have more safety in the classification of critical/non-critical patients.	6.1 ± 1.0 6.0	6.3 ± 0.7 6.0	5.8 ± 1.2 6.0	0.010	0.006	<0.001
	4. I expect to/I can treat life-threatening situations faster.	6.2 ± 0.9 6.0	6.2 ± 0.8 6.0	5.7 ± 1.3 6.0	<0.001	0.517	<0.001
	5. I expect/could to expand my knowledge in trauma care.	6.4 ± 0.9 7.0	6.5 ± 0.7 7.0	6.1 ± 1.1 6.0	0.003	0.371	<0.001
COMMON PROCEDURES	1. I feel safe in airway management	5.1 ± 1.0 5.0	5.9 ± 0.8 6.0	5.4 ± 1.2 5.0	0.001	<0.001	<0.001
	2. I feel safe in proper handling with neck collars	5.7 ± 0.9 6.0	6.4 ± 0.7 6.0	6.3 ± 0.9 7.0	<0.001	<0.001	0.977
	3. I feel safe in removing a helmet	5.2 ± 1.0 5.0	5.8 ± 0.9 6.0	5.9 ± 1.2 6.0	<0.001	<0.001	0.125
	4. I feel safe in the rescue off the vehicle (extrication)	4.8 ± 1.0 5.0	5.8 ± 0.8 6.0	3.8 ± 1.9 4.0	<0.001	<0.001	<0.001
	5. I feel safe in treatment of traumatological emergencies	4.8 ± 1.0 5.0	5.9 ± 0.7 6.0	5.7 ± 0.8 6.0	<0.001	<0.001	<0.001
RARE PROCEDURES	1. I feel safe in thoracic needle decompression	2.2 ± 1.5 1.0	4.5 ± 1.5 5.0	2.8 ± 1.7 2.0	<0.001	<0.001	<0.001
	2. I feel safe in the proper handling of the spineboard	5.2 ± 1.1 5.0	6.1 ± 1.0 6.0	5.8 ± 1.1 6.0	<0.001	<0.001	0.008
	3. I feel safe in the proper handling of the pelvic sling	3.9 ± 1.6 4.0	6.0 ± 0.9 6.0	5.6 ± 1.1 6.0	<0.001	<0.001	<0.001

A *p*-value of <0.05 is considered statistically significant

Table 4 Linear regression with one major question as a dependent variable at time point t2

Dependent variable: I feel safe in treatment of traumatological emergencies			
Predictor	Coefficient (SE)	95% CI	*p*-value
Work experience	0.00 (0.02)	−0.03 – 0.03	0.859
I use the ABCDE-structure in prehospital trauma care	0.09 (0.04)	0.01–0.18	0.036
I feel safe in thoracic needle decompression	0.10 (0.03)	0.05–0.15	<0.001
I feel safe in proper handling with neck collars	0.43 (0.05)	0.33–0.53	<0.001
After one year, my expectations have been fulfilled	0.05 (0.05)	−0.04 – 0.15	0.275
I am anxious regularly to do further studies by medical journals.	0.03 (0.04)	−0.04 – 0.10	0.404
Sex	−0.07 (0.09)	−0.25 – 0.10	0.400

A *p*-value of <0.05 is considered statistically significant

effective. The current study part used questionnaire survey to identify subjective safety. The results show that expectations for the course were exceeded after one year ($p = 0.002$). However, expectations for knowledge and specific questions to safety were met as expected or increased rated after the course, but significantly lower after one year than before the course. Skills, especially rare skills, were mostly significantly better. Figure 1 shows the means of the factors. As described in Table 1, the medians are stable, but Fig. 1 shows the different development of the mean values over the time points.

Expectations

The medians in the expectation-group show a steady value of 6, even after one year. The expectation for "expand my knowledge" had the highest value before the course (7) and is also met after the course, but dropped after one year to median 6. This might be due to the fact that the course had not enough power to retain knowledge over one year. That knowledge quickly evaporates is not unknown [17]. On the other hand, Mohammad et al. showed that knowledge and skills in the related ATLS courses are increased first, but then declined after half a year, without knowing whether Mohammad et al. have determined this as subjective or objective parameters. The present data showed this change only in the knowledge. The problem of knowledge verification by pre/post-test has already been discussed [16].

However, the course increases the safety in a direct pre/post-comparison, but individual assessments on safety aspects regarding kinematics, classification and speed

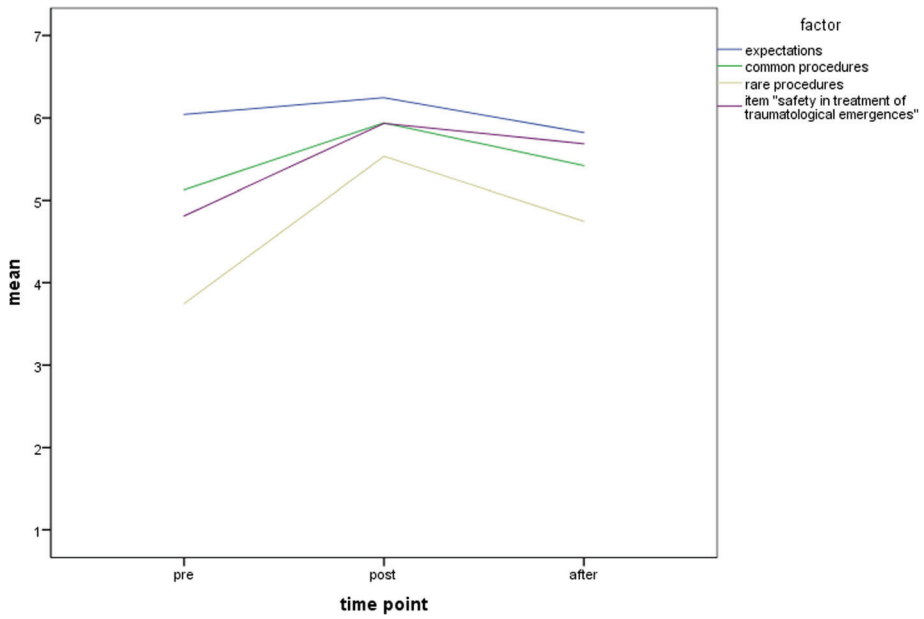

Fig. 1 The figure shows the summarized mean values according to the factors, as well as the single major issue "safety in treatment of traumatological emergencies". The x-axis shows the three time points

decrease after one year. A short-term effect in direct pre/post comparison is also described in other studies [18].

Interestingly, nearly all mean values dropped from t0 to t2 significantly, but only with small differences. By contrast the expectations were exceeded significantly after one year ($p < 0.001$). This is remarkable, because participants were told to attend the course and did not participate at their request and it is known that compulsory lessons are sometimes worse evaluated than voluntary events [19].

By the participants, the major issue "safety in the treatment of traumatological emergencies" was in the pre/post comparison as well as after one year significantly higher rated than before the course (both $p < 0.001$). This question is the major issue and is highlighted as single item in Fig. 1.

Preparation

The value for preparation by course manual is from t0 and t2 not different ($p = 0.95$). T1 is significantly higher evaluated as t0 and t2, possibly because it was noticed that in post-test the questions can be solved with the knowledge of the manual. Münzberg et al. showed that the participants of ATLS courses had best evaluated the skills and scenarios [20]. Most German participants in medical courses prefer practical trainings to theoretical knowledge. Because the manual had 648 pages, perhaps a narrower manual would be recommended as well as new technologies (e.g. mobile apps).

Common procedures

All common skills were assessed better after one year than before the course, except for safety in the extrication procedure. A reason could be that extrication procedures may be rare in urban emergency services, and the trained procedure of Rapid Extrication must probably be constantly trained to be fit. Therefore, it is interesting that this procedure was assessed as a common procedure, as well as airway management. For German paramedics, invasive airway management skills are certainly not a regular procedure; however, this skill may be well-trained with supraglottic devices in the context of regularly resuscitation training. Nevertheless, the assessment of respiratory management is even better after one year.

As the use of the cervical collar is a regular skill, the more astonishing is it that PHTLS courses improve the safety in this skill right after the course, as well as after a year ($p < 0.001$). In the period, up to one year, own training could also lead to improvement. However, this still appears to be important because the correct application of the cervical collar is often faulty [21].

Rare procedures

Overall rare procedures show the greatest changes. The safety of using the spineboard is significantly better after one year than before the course ($p < 0.001$), possibly also by own training or application during this time. Although the estimate t2 is on mean lower than t1 ($p = 0.001$), the median is still the same as directly after the course. The fact that the spineboard slips to the rare procedures can be explained in the factor analysis: the difference from eigenvalue for rare procedures (0.551) to common procedures (0.545) is low. It is to be assumed that further analyses shift the spineboard to common procedures.

Thoracic needle decompression is with an incidence around 1.1% extremely rare [14]. Thus, the initial uncertainty in this measure is not surprising. The rating in this study showed an extreme rise and fall immediately after the course and a year after. The value is the lowest after a year overall, but it is even better after one year than before the course ($p < 0.001$). However, the results of safety in this skill are widely varying.

Major issue

In further question one year after the course, participants agree subjectively to an improvement in patient care after the training. A similar result is also found in a Swiss study in which 85% of the participants see advantages after the introduction of PHTLS [22].

To detect influencing factors concerning our lead issue and major question, safety in treatment of traumatological emergencies, the regression analysis shows that a structure in assessment and treatment is essential for subjective safety, as well as safety in skills and procedures. Work experience or therefore age does not matter, which means that in this study inexperienced paramedics feel equal safe as experienced paramedics – after the training. This is interesting, because young professionals are usually in greater temporal proximity to their up-to-date school-based or university-based knowledge. With increasing experience, the experience will be of greater importance than the systematic knowledge base [23]. The ideal learning psychological approach is the ability to form illness scripts of pattern recognition, which is learned with increasing experience and to combine this with strategies for solving problems supported by e.g. checklists or treatment structure [24]. But also the willingness of these participants to learn and to participate in further training was equally distributed through all ages.

That means that subjective safety in prehospital trauma care depends on structure (ABCDE) and well -trained skills and procedures, independent of age or work experience. The PHTLS-courses use the well-known ABCDE-structure, but presumably this can be transmitted to any assessment/treatment structure.

Challenges and limitations

This study-part focuses on subjective evaluation and cannot clarify to what extent self-assessment and actual competence match. It is known that self-assessments are not reliable to assess quality medical treatment [25]. For the assessment of students' capabilities in emergency situations there are further assessments discussed, which differ from ordinary OSCEs [26]. The professional experience also correlates differently with the actual experience, in the sense of patient contacts and corresponding measures [27]. Kreinest et al. showed that the correct application of cervical collars and self-assessment therefore were diametrically divergent [21]. In this context, it seems important to point out that the present study deliberately investigated items for subjective assessment. In order to reconcile self-assessment and reality, it is important to provide feedback for the participants. Consistent feedback structure is an important part of the PHTLS courses. Because hundreds of paramedics cannot be trained by the same instructor team, we have discussed this influence in the study protocol [9]. Because the course regulations for that courses have a high standard in internal quality assurance and a well-structured instructor manual, we assume that there is no relevant or just minimal influence. Matching subjective with objective measurement is investigated in other study parts of the EPPTC-Trial [9].

Whether safety or assessment dropped, or whether the participants have become more critical, cannot be finally clarified with the present questionnaire. It was also discussed, to which extend expectations of subjective safety must be met. The participants had high expectations before the course, which must be achieved. This may be a weakness of the questionnaire or an imprecise question. Subjective safety and confidence are closely intertwined, without being able to separate them further [28]. However, the increased subjective safety should be discussed in context of reduced knowledge and specific safety after one year. If this leads to the fact that the participants now have furthermore confidence, without an objective basis for it, it would be fatal for the patients. This must be clarified in the video analyses as part of our trial [9].

In statistical analysis, we saw, especially in the expectation-group, significant differences between the time points, with small differences between the mean values but stable medians. But the difference in the consideration and result of mean versus median in this method is obviously not only a discussion point for us [29].

Even if skills or procedures in this context are understood as the craftiness of the hand, the questionnaire cannot clarify whether the participants understand the manual implementation or the associated knowledge regarding the indication, contraindication, etc. in the case of questions about skills.

Conclusion

The result shows that the expectations of the participants in the course were met even after one year. In the pre/post comparison, an increased evaluation is possible almost all subjects. The subjective safety in trauma care is significantly better even one year after the course. Decisive are (ABCDE)-structure and safety in skills. Most skills are also rated better after one year. Knowledge and specific safety are assessed worse after one year.

Additional file

Additional file 1: Rotated component matrix. (DOCX 28 kb)

Abbreviations

ATLS: Advanced trauma life support; EMS: Emergency Medical Service; PHTLS: Pre-Hospital trauma life support

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Availability of data and materials

No data or materials to share.

Authors' contributions

DH is the principle investigator of the study, developed study design and questionnaires, collected data, performed statistical analysis, drafted the manuscript and did the final writing. SB, MH assistant to develop study design, assistant in development protocol, data interpretation, reviewed final writing and gave expert tips. RL assisted to develop the study design and assisted in statistical analysis. VP assisted to develop questionnaires and factor analysis. MM assistant to develop study design reviewed final writing and gave expert tips. US, PG gave expert tips. All authors read and approved the final manuscript and approved the use of data respectively publication.

Ethics approval and consent to participate

The Ethics Committee of the Medical Faculty of the Eberhard Karls University of Tuebingen and the University Hospital approved the study proposal, number 197/2013BO2, on May 24, 2013. The study is registered in the German Clinical Trials Register with the ID DRKS00004713. Informed consent was obtained from all individual participants included in the study.

Consent for publication

Data collection, coding, routing and analysis were in accordance with data protection policy of Tübingen University. Participants gave written consent for analysis and publication, without showing individual personal data.

Competing interests

DH is PHTLS instructor. The other authors declare that they have no competing interests.

Publisher's Note

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2.6 Entwicklung und Validierung einer Checkliste zur Beurteilung der Videoaufnahmen des Szenario-Trainings

Häske D, Beckers SK, Hofmann M, Lefering R, Preiser C, Gliwitzky B, Grützner PA, Stöckle U, Münzberg M (2018) Performance Assessment of Emergency Teams and Communication in Trauma Care – explorative analysis, development and validation of the PERFECT-Checklist; part of the prospective longitudinal mixed-methods EPPTC-trial. Submitted. (Häske et al. 2018)

Performance Assessment of Emergency Teams and Communication in Trauma Care **(PERFECT Checklist) – explorative analysis, development and validation of the PERFECT Checklist: part of the prospective longitudinal mixed-methods EPPTC trial**

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Abstract

Background

Courses in trauma care are well structured, but the tests are rarely validated. We are evaluating the impact of pre-hospital trauma trainings on participants and patient care. This article concerns the development and validation of a checklist to assess trauma trainings. The checklist uses a sum score to enable an objective evaluation and comparability of scenarios or even real trauma patient care.

Methods

We used videos recorded at the time points directly before (t0), directly after (t1) and one year after (t2) trainings to develop the PERFECT checklist (Performance Assessment of Emergency Teams and Communication in Trauma Care). The videos were assessed using semi-qualitative/linguistic analysis as well as expert panel appraisal and recommendations using the Delphi method. The checklist was tested for validity and reliability.

Results

The inter-rater reliability (ICC=0.99) and internal consistency (α=0.99) were high. Concurrent validity was moderate to high (r=0.65 – r=0.93 (p<0.001)). We included scales for procedures, non-technical skills, technical skills and global performance. The procedures were done faster in the mean over the timeline (t0: 2:29, 95%CI 1:54-3:03 min., t1: 1:11, 95%C 0:53-1:30 min, t2: 1:14, 95%CI 0:56-1:31 min.). All experts rated the recorded scenarios at t0 with the lowest sum score (mean 31±8), with a significantly better performance of the teams at t1 (mean 69±7). The performance at t2 (mean 66 ± 13) was slightly lower than at t1, but still better than at t0. At t1 and t2, linguistic analysis showed a change in the team leader's communication behaviour, which can be interpreted as a surrogate parameter for reduced stress.

Conclusion

The PERFECT checklist has a good validity and high reliability for assessing trauma procedures and teamwork.

1 INTRODUCTION

The care for seriously injured patients still deserves considerable attention because a large number of these patients are young, of a working age and the injuries generally have major physical, emotional and socio-economic consequences[1, 2]. Today, there is a wide variety of offers for training in acute and emergency care, for example for trauma, resuscitation, pre-hospital or in-hospital emergency situations.

1.1 Problem description

Although these courses are well structured, in accordance with guidelines, and usually conclude with a written (multiple choice) and practical success evaluation[3–7], the tests are rarely and not consistently validated[8]. In the study of medicine for the objective assessment of skills and abilities, OSCEs (objective structured clinical examination) are used and these are a valid and reliable tool[9–11].

1.2 Available knowledge

There are numerous tests for non-technical skills[12] and technical skills[13, 14], as well as for trainings or real patient care[15]. Although early experience in OSCE in emergency medicine has been published[16], there is just little literature compared to other medical subjects[17].

1.3 Rationale

In our study, we investigated how an emergency medical service (EMS) system is influenced by systematic training. The reason for a new approach in this EMS was a decreased employee satisfaction and loss of quality in patient care[18]. We knew that the chosen training models have no significant impact on mortality [19], so we chose a prospective longitudinal mixed-methods design, including video analysis of training sequences, to view the impact in its entirety [20]. However, existing assessments or OSCEs were not suitable for verifying changes other than mortality from training, because they do not have the required technical, cognitive and communicative characteristics.

1.4 Specific aims

This article describes the explorative, semi-qualitative development of a checklist for assessment and verification of video analyses of emergency medical trainings. The checklist should enable an objective evaluation and comparability of scenarios or even real trauma patient care by means of point scores.

2 METHODS

2.1 Context

This analysis was part of the mixed-methods longitudinal EPPTC (Effect of Paramedic Training on Pre-hospital Trauma Care) study evaluating the subjective and objective changes after Pre-hospital trauma life support (PHTLS) courses in participants and real patient care. The complete study is described in the previously published study protocol as well as partial results[20–22].

2.2 Intervention

To improve the pre-hospital care of trauma patients, the medical director of EMS Wiesbaden (Germany) decreed that all of the approximately 300 paramedics had to be trained in PHTLS.

The two-day PHTLS courses teach paramedics and emergency physicians how to improve pre-hospital care for trauma patients[23]. These courses can be regarded as a worldwide standard in the pre-hospital care of seriously injured patients. They use different teaching methods (e.g. lectures, practical case studies, skill training), with a close instructor-participant ratio (1:4), many practical activities and

continuous interaction. The courses are conducted by certified instructors (physicians, paramedics, etc.). The priority-based structure ABCDE (Airway, Breathing, Circulation, Disability and Exposure) is taught intensively and practiced in scenario-based training sessions, as well as various skills. The PHTLS statements are similar to the key recommendations of the "German Guideline on Treatment of Patients with Severe and Multiple Injuries"[7].

2.3 Study of the intervention

To assess the impact of the interventions, we chose a mix methods approach. For the longitudinal analysis, we used three measuring points. The first measuring point was just prior to the course (t0), the second measuring point was directly after the course (t1) and the third measuring point was one year after the course (t2). The current publication is concerned with the analysis of videos of the trainings, using qualitative, quantitative and linguistic approaches and with the development of a checklist to assess and to compare the performance of the teams in the training videos in an objective way similar to an OSCE.

2.4 Measurements

We used detailed video analysis for the measurements. For this purpose, three videos were selected at random for each measuring point. To create the scenario-checklist, the videos were analysed and the results were reviewed, adapted and refined by an expert panel.

The videos were recorded during PHTLS courses for paramedics in context of the overall project (EPPTC-study)[20]. Recording times were at each measuring point. A camcorder (Panasonic HD Camcorder HC-V100) on a tripod was used for recording and data was stored on SD Memory Cards. The scenarios simulated the pre-hospital care of severely injured patients. Amateur actors represented patients with a leading severe thoracic injury and dislocated ankle fracture, however, always with different causes and stories. Injuries should correspond to an Injury Severity Score (ISS) of approx. 38 (abbreviated injury scale (AIS): AIS 0-0-5-2-3-1). For the present analysis, three videos from each of the three measuring points were randomly selected from the records.

2.4.1 Explorative analysis

To gain an impression of the data, we performed an explorative analysis before validation. First, we analysed the timing of the measurements, differentiated according to the three measuring points. Second, we ran a qualitative analysis to develop items for the checklist. Data coding and analyses were performed with the qualitative software program MAXQDA 12 (Berlin, Germany) and followed the methodological concept of a directed qualitative content analysis[24]. Team performance, medical measures, communication characteristics and behaviour were encoded directly into the program. Communication from the team leader to the patient and to the team was transcribed and coded for linguistic analysis.

For linguistic quantitative analysis of the communication between the team leader and team, we used the program "Linguistic Inquiry and Word Count (LIWC)" (Lawrence Erlbaum Associates Inc, Texas). This method categorises word count, sentence punctuation, negation (no, never, not), proportion of words with more than 6 letters (big words), approvals (yes, OK, mmhmm) and first person plural (us, our, us) as well as psychological classifications like positive emotions (happy, handsome, good), anger (hatred, annoying) and cognitive processes (cause, knowledge, effect, perhaps) and fillers[25, 26]. The program counts the words in the transcribed text and calculates the percentage of total words that match the

specific categories. This analysis did not include other aspects of phonetic language with para-verbal and non-verbal events.

2.5 Expert panel

An expert panel consisting of emergency physicians, medical didactics, sociologists and human scientists (DH, SB, MH, CP, BG, MM) assessed the results of the video analysis. The Delphi method was used to discuss the codes for the checklist and to discuss the applicability for the practical assessment of scenarios and to reach a final consensus for the determination of the content validity.

Subsequently the inter-rater reliability was tested. Videos of all three time points (t0, t1, t2) were blinded to the time points and then assessed by six experienced trauma instructors (physicians, paramedics with Advanced Trauma Life Support (ATLS) / PHTLS certificate) independently.

2.6 Statistical analysis

To assess the construct validity, we performed a principal component factor analysis (PCA) with varimax rotation. Eigenvalues greater than 0.5 were chosen for the component factors, and factor charges of at least 0.5 were sought for the interpretation of the factor structure.

To calculate the internal consistency of the scales, we used Cronbach's Alpha. For concurrent validity we correlated the global performance scale, non-technical scale, primary assessment scale and procedure scale.

An inter-rater reliability > 0.8 is recommended[27]. We used the intra-class correlation (ICC), because of continuous variables and more than two raters. Because the evaluation is usually done by a single rater, a two-way random model with single measure ICC (3.1) was used[28].

Pearson coefficient was used to describe interval-scaled correlation. A two-tailed p-value < 0.05 was usually considered as statistically significant. For continuous variables, data is shown as mean ± standard or 95%-confidence interval. For categorical variables, percentages are presented. All data were analysed using the statistical software SPSS (Version 24.0, IBM Inc., Armonk, NY, USA).

2.7 Ethical Considerations

The Ethics Committee of the Medical Faculty of the Eberhard Karls University of Tübingen and the University Hospital approved the study proposal, number 197/ 2013BO2. The study is registered in the German Clinical Trials Register with the ID DRKS00004713.

Data collection and analysis were aligned with the data protection officer at the University of Tübingen and the University Hospital of Tübingen. The video recordings were voluntary for the participants and were made after their written consent.

3 RESULTS

3.1 Explorative analysis

As part of the qualitative analysis, we ultimately generated 84 codes. The extensive codes gave a differentiated picture of the training but were too complex to use during training or possibly during patient care. Examples of differentiations are the differences between, for example, oxygen applied, oxygen administration ordered and oxygen administration controlled. During the Delphi process of the Expert Panel, the codes were reduced to items suitable for the checklist.

The chronology of primary assessment showed that most of the procedures were performed earlier at t1 and (t2) as t0 and the confidence intervals became mostly narrower. On average, the procedures were carried out at minute 2:29, 95%CI 1:54-3:03 at t0, at minute 1:11, 95%C 0:53-1:30 at t1 and at minute 1:14, 95%CI 0:56-1:31 at t2. Figure 1 shows the corresponding results with ABCDE approach.

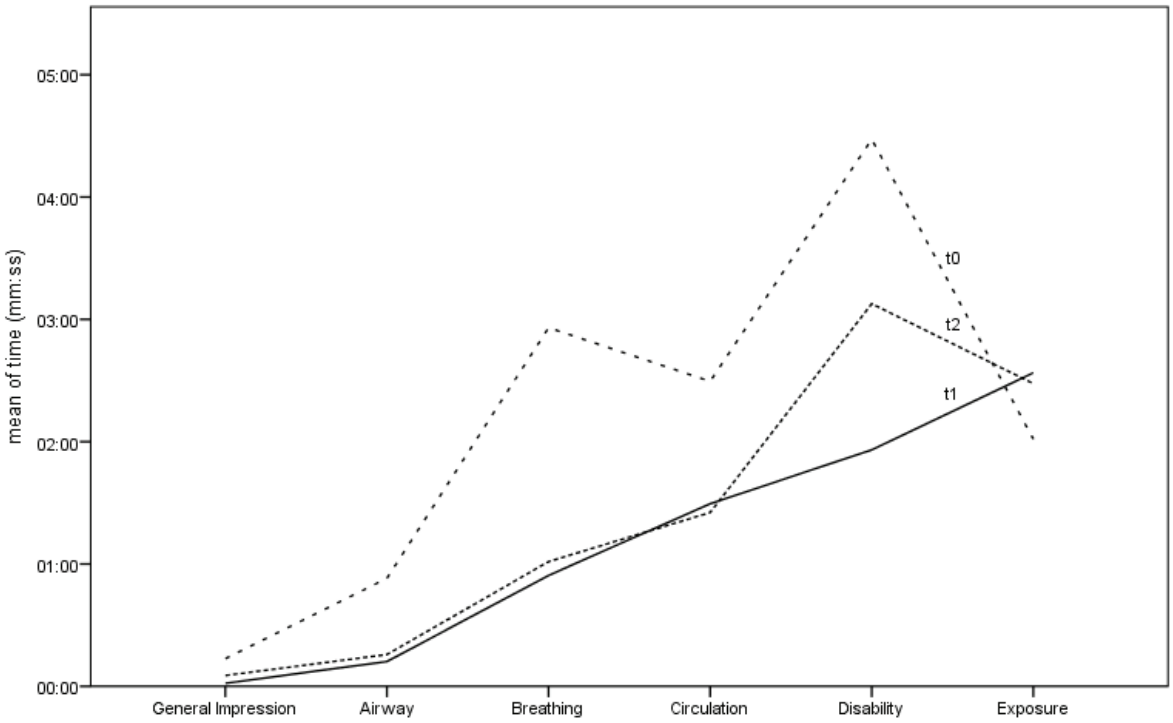

Figure 1: The figure shows the mean time of the measures performed in the primary assessment, grouped according to three different measuring points. The graph t1 fits best the (linear) ABCDE-approach, followed by the graph t2. T0 has the most divergence from the t1.

The linguistic analysis of the communication of the team leader with the team showed a changed communication behaviour from measuring point to measuring point. Figure 2 shows the changes in the different categories. The obvious change is the increase of big words and articles, while the cognitive and social words, as well as emotions, decrease.

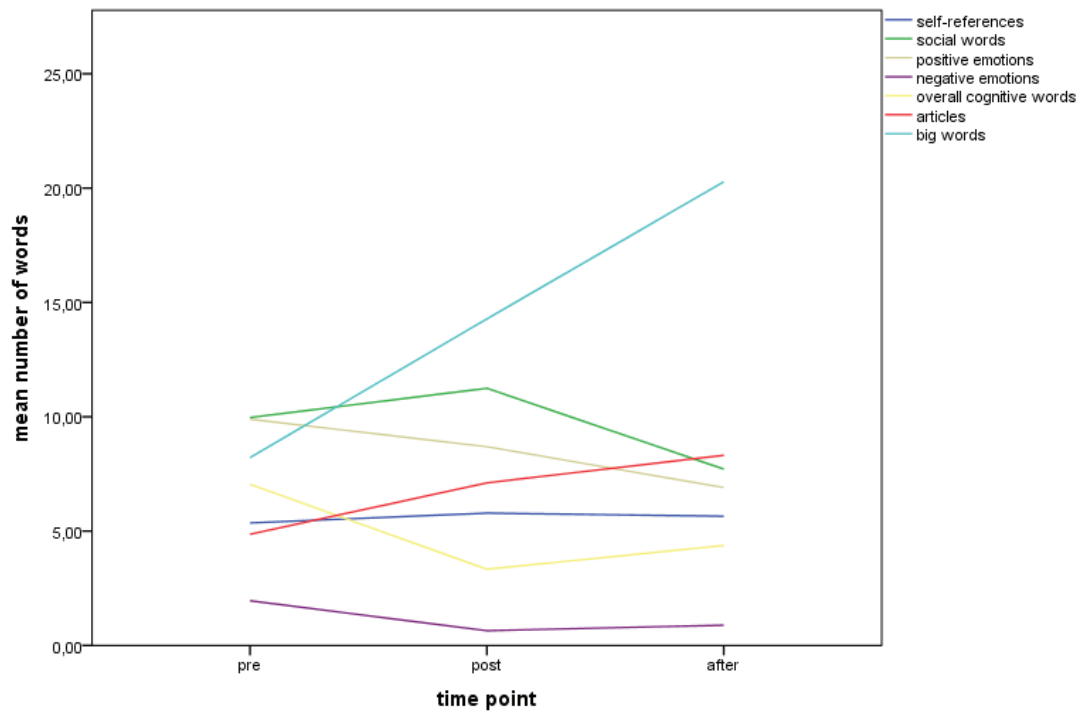

Figure 2: Linguistic analysis of the communication from the team leader to the team, over the three times points t0, t1, t2. The increase of big words and articles is obvious, while the cognitive and social words, as well as emotions, decrease.

3.2 Expert Panel

Based on the analysis and the expert experience, the checklist *"**Perf**ormance Assessment of **E**mergency Teams and **C**ommunication in **T**rauma Care"* (**PERFECT Checklist**) was created. It includes seven scales with a minimum of 6 points and a maximum of 100 points (Supplement).

The first scale "primary assessment" includes 25 items with the options "application executed" and "timely", which means that each item allows two, overall up to 50 points. The scale "secondary assessment" includes four items with the options "application executed" and "timely". The value of each option was set at 0.5 points, so four points are the possible maximum. Additionally, the time of interventions can be documented.

The expert panel defined a scale "procedures" with five items, in which the most important characteristics for trauma care were defined, which cannot be mapped in other scales. Each item has the value of two points, which means overall twelve points.

The scale "technical skills" includes five skill items and an additional overall item. Each item has a checkbox for "executed" and "indication correct?" as well as a 4-point-performance scale. But only the "skills overall" rating is included in the calculation of the checklist points, with a maximum of six points.

The scale "trauma communication" includes eight items (simply rated) with specific communication points or signal words which were recognised in the qualitative analysis. The maximum is eight points.

The qualitative analysis showed very heterogeneous non-technical skills of the teams. The expert panel chose four items regarding situation awareness and decision-making, leadership and teamwork,

workload management and communication. A 4-point performance scale was added, which makes a maximum of 16 points.

Finally, a 6-point "global performance scale" was added to incorporate the experience and judgment of the raters (figure 3).

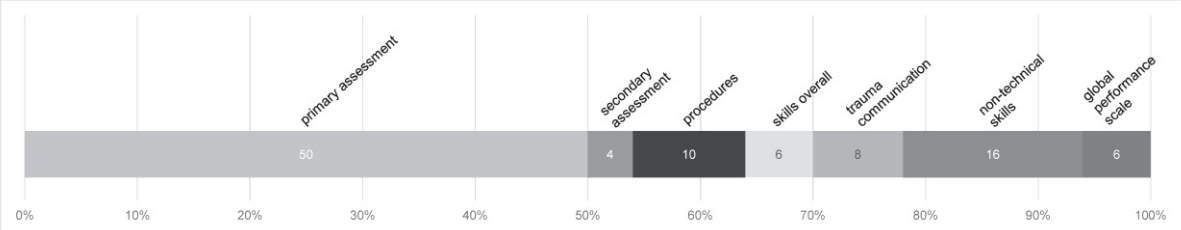

Figure 3: Proportions of the scales in the checklist, based on their maximum points.

3.3 Validity and reliability

For validation, 36 videos were reviewed by experts as described previously. All experts rated the recorded scenarios at t0 with the lowest sum score (mean 31 ± 8), with a significantly better performance of the teams at t1 (mean 69 ± 7). At t2 the performance was still better (mean 66 ± 13) than at t0, but slightly lower than at t1. This inter-rater agreement is visualised in Figure 3.

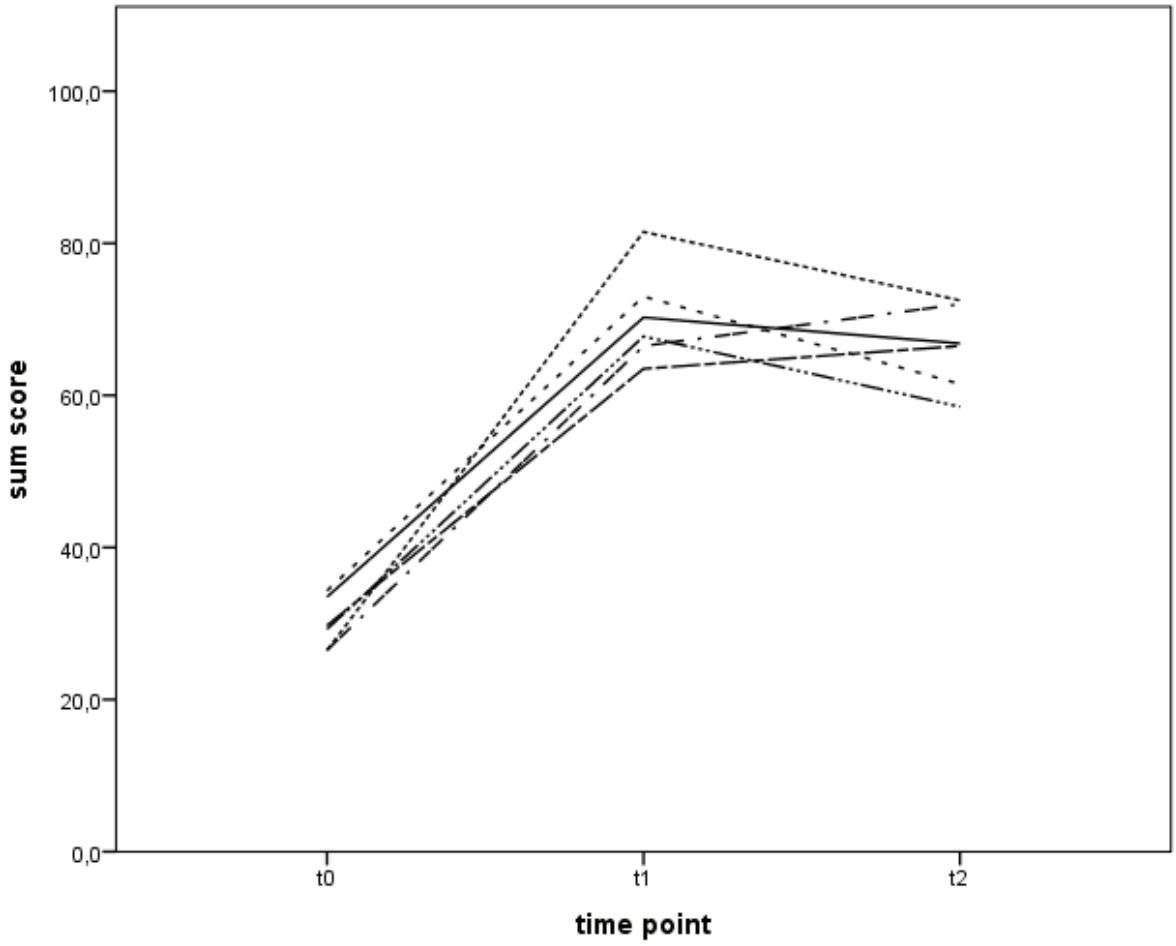

Figure 3: This Figure shows the high inter-rater agreement (ICC=0.993) of the six raters as well as the different appraisal at different measuring points. The evaluation of the reviewers shows a significantly better

performance of the teams after the course than before, but with a slight deterioration from right after the course to one year later.

3.4 Construct validity

The Kaiser-Meyer-Olkin Measure of sampling adequacy was 0.848, Bartlett's Test of Sphericity was χ^2=207.456 (p<0.001), therefore data showed a good eligibility for PCA.

Three factors with eigenvalues ≥0.5 were extracted by PCA and explained 89.7% of the overall variance (Supplement). The first factor explained 66.6% of the total variance and included 5 items with factor loadings between 0.83 and 0.92. The second factor explained 14.1% of the variance and comprised just one item with a factor loading of 0.93. The third factor also comprised one item and explained 9.0% of the variance with a factor loading of 0.98. The first factor included the primary assessment, procedures, trauma communication, non-technical skills and the global performance scale and, in accordance with the rating of the experts, explained the most important aspects regarding the quality of simulated trauma care. The second factor included the secondary assessment, which was rarely completed in contrast to the other scales. The third factor was well explained by the technical skills.

3.5 Concurrent validity

The sum score and the sum of the primary assessment showed an excellent correlation (r=0.916, p<0.001), as well as the sum score with the non-technical skills (r=0.912, p<0.001) and the sum score with the global rating scale (r=0.912, p<0.001).

Table 1: Concurrent validity. * means p<0.001, for two-sided tests. Non-technical skills and global performance scale show the highest correlation (r=0.930), followed by non-technical skills and procedures (r=0.825).

	Primary assessment	Procedures	Non-technical skills	Global performance scale
Primary assessment	-			
Procedures	0.654*	-		
Non-technical skills	0.745*	0.825*	-	
Global performance scale	0.806*	0.774*	0.930*	-

3.6 Internal consistency of the scales

Scales with several items have a good consistency: Cronbach's alpha was 0.93 for the 27-item-scale "primary assessment", 0.87 for the 4-item-scale "secondary assessment", 0.95 for the 6-item-scale "procedures", 0.93 for the 8-item-scale "communication", 0.96 for the 4-item-scale "non-technical skills" and overall 0.99.

3.7 Inter-rater reliability

Inter-rater reliability showed very good values overall and for specific scales. ICC was for the "primary assessment" 0.93, for "secondary assessment" 0.85, for "procedures" 0.93, for the 8-item-scale "communication" 0.93, for "non-technical skills" 0.96 and overall 0.99.

4 DISCUSSION

The aim of trauma courses is to gain assurance trauma skills and to act better and faster in life-threatening situations by improving the knowledge and the structured care of trauma patients. Therefore, cognitive knowledge, technical skills, and procedures with clinical judgment are necessary and elementary for subjective safety in trauma care[22].

A variety of trauma courses are available, but the existing assessments did not match our needs. The PERFECT checklist was developed using qualitative and quantitative analysis and the expertise of experienced academics, clinicians and trauma instructors. The result combines the assessment of (technical) skills, non-technical skills and procedural performance, which are essential for clinical competence in trauma care.

The qualitative analysis gathered data in detail. In the end we separated items in, for example, "indicated", "executed", "executed correctly", "executed without indication". In a second step, we had to decide between analytical details whose clinical relevance may be marginal and practicality of the checklist during scenarios. We chose to focus on clinical aspects and practicality and therefore combined several items in groups with the same clinical relevance, for example we established the item “looked for possible respiratory failure” instead of the detailed items cyanosis, thoracic excursions, breathing work, and diminished tidal volume.

Linguistic analysis was developed in the 1990s to analyse cockpit communication regarding language errors and workload[29]. It resulted in recommendations to keep communication simple by short and clear words, because under increasing stress the brain’s memory capacity decreases to a few seconds[30]. The transferability of the findings to acute medicine is widespread and acknowledged[31, 32]. Our linguistic analysis of the communication from the team leader to the team at measuring point t0 to t2 showed an increasing number of words in the categories “big words” and "articles" (Figure 2). The relationships may be multifactorial, but with the knowledge that communication, and respectively speech, becomes shorter and monosyllable under stress[30] these categories can be indicated as surrogate parameters for stress. Stress has a relevant influence on the technical performance, but can be compensated by non-technical skills[33]. In our analysis, we interpreted the increasing number of words in the categories "big words" and "articles" as a surrogate marker, which indicates declined stress levels over the measurement times. This result is also reflected in the assessment of the course participants, as their subjective safety in the care of severely injured patients improved over the measuring points and after the course[22]. Additionally, our "non-technical skills scale" and "primary assessment scale" showed a good correlation with r=0.745.

In the qualitative analysis of the scenarios, the difference in the non-technical skills of the teams was remarkable. Although the PHTLS system does not provide any NTS teaching content, they have been added to the checklist. For the NTS scale we used a 4-point performance scale, which was labelled and matched with the relevant literature[31, 32]. Wallin et al. have also evaluated the impact of training on medical students, with improved clinical skills, but there was no improvement in teamwork[34]. In contrast, in our exploration we saw a significant improvement in teams with mixed experience, but these findings must be confirmed with an adequate sample size.

The checklist developed shows a very good reliability and validity. Our ICC (0.99) is notably higher than the ICC of similar assessment tools (0.6-0.8[35–37]). The appraisal of the expert panel was in our opinion more important than a calculation of a content validity index, especially because the content validity is

always subject to a certain subjectivity and it is strictly speaking not a test quality criterion[27]. Concurrent validity shows high correlation. Along with this, we have established the equally well correlated global performance scale, with which Dankbaar et al. had already had positive experiences[38]. Therefore, it is important to have well-trained users of the checklist.

The different coding of the scales was also discussed in the expert panel. For classical OSCE, binary codes are often used but are at least equal to multi-level rating[39]. Frequently, technical skills tend to use binary rating scales rather than communicative ones[40], and their number of points or range can vary widely[35, 37, 41]. We decided to use binary coding in the assessments and procedures and used 4-point rating scales for NTS and the skill performance. The global rating scale has a 6-point rating scale.

Qualitative video analysis also showed that some teams met all the points on the scale, but they did not perform in a timely manner, in any structure or at speed, or in terms of rapid identification and management of life-threatening conditions. We also knew that a structured patient treatment has a significant influence on subjective safety in trauma care[22], which is why the expert panel had implemented the scale "procedures" and even weighed their points twice.

5 LIMITATIONS

The biggest weakness of the checklist is the impossibility to make a differentiated assessment of the skills. This concerns the individual skills (execution, indication, performance, etc.) as well as the embedding into the points system of the checklist to ensure the comparability of scenarios. For example, a scenario with three skills could theoretically receive a triple skill score, while a scenario with only one skill could be very well performed but would have automatically scored less on the one skill. So we decided to include only one overall skill item in the calculation, but to include differentiated skills as a memo for instructors.

In spite of very good inter-rater reliability, we must accept that raters always have an influence on an objective assessment, which cannot be controlled[42]. Our checklist was developed on scenarios of trauma training and not during real patient care and so no statement can be made about how it works in real patient care.

6 CONCLUSION

The importance of a systematic approach instead of a personal approach to team training in high-risk emergency care is crucial[43] and vitally important for improving public health and potentially reducing the mortality of patients. This requires appropriate training, as well as validated opportunities to review long-term training success. With the help of the PERFECT checklist, a validated tool is now available for our needs.

7 CONCLUSION

The importance of a systematic approach instead of a personal approach to team training in high-risk emergency care is crucial[43] and vitally important for improving public health and potentially reducing the mortality of patients. This requires appropriate training, as well as validated opportunities to review long-term training success. With the help of the PERFECT checklist, a validated tool is now available for our needs.

Competing interests

David Häske is a PHTLS instructor. The other authors declare that they have no competing interests. The study is partly funded by the German Association of Emergency Medical Technicians (Deutscher Berufsverband Rettungsdienst e.V. DBRD). There is no influence in the study design, data collection and analysis, decision to publish, or preparation of the manuscript by the sponsors.

Authors' contributions

David Häske is the principle investigator of the study, developed the study design, collected data, did the explorative analysis, performed statistical analysis, was on the expert panel, drafted the manuscript and did the final writing.
Stefan Beckers and Marzellus Hofmann assisted in developing the study design, assisted in developing the protocol, were on the expert panel, reviewed the final writing and gave expert tips.
Rolf Lefering assisted in developing the study design and assisted in the statistical analysis.
Bernhard Gliwitzky worked on the study logistics, was on the expert panel, reviewed the final manuscript and gave expert tips.
Christine Preiser assisted with the qualitative analysis, reviewed the final manuscript and gave expert tips.
Matthias Münzberg assisted in developing the study design, was on the expert panel, reviewed the final manuscript and gave expert tips.
Ulrich Stöckle and Paul Grützner gave a final review and expertise in the planning phase.
All authors read and approved the final manuscript and approved the use of data regarding the publication in the context of the dissertation.

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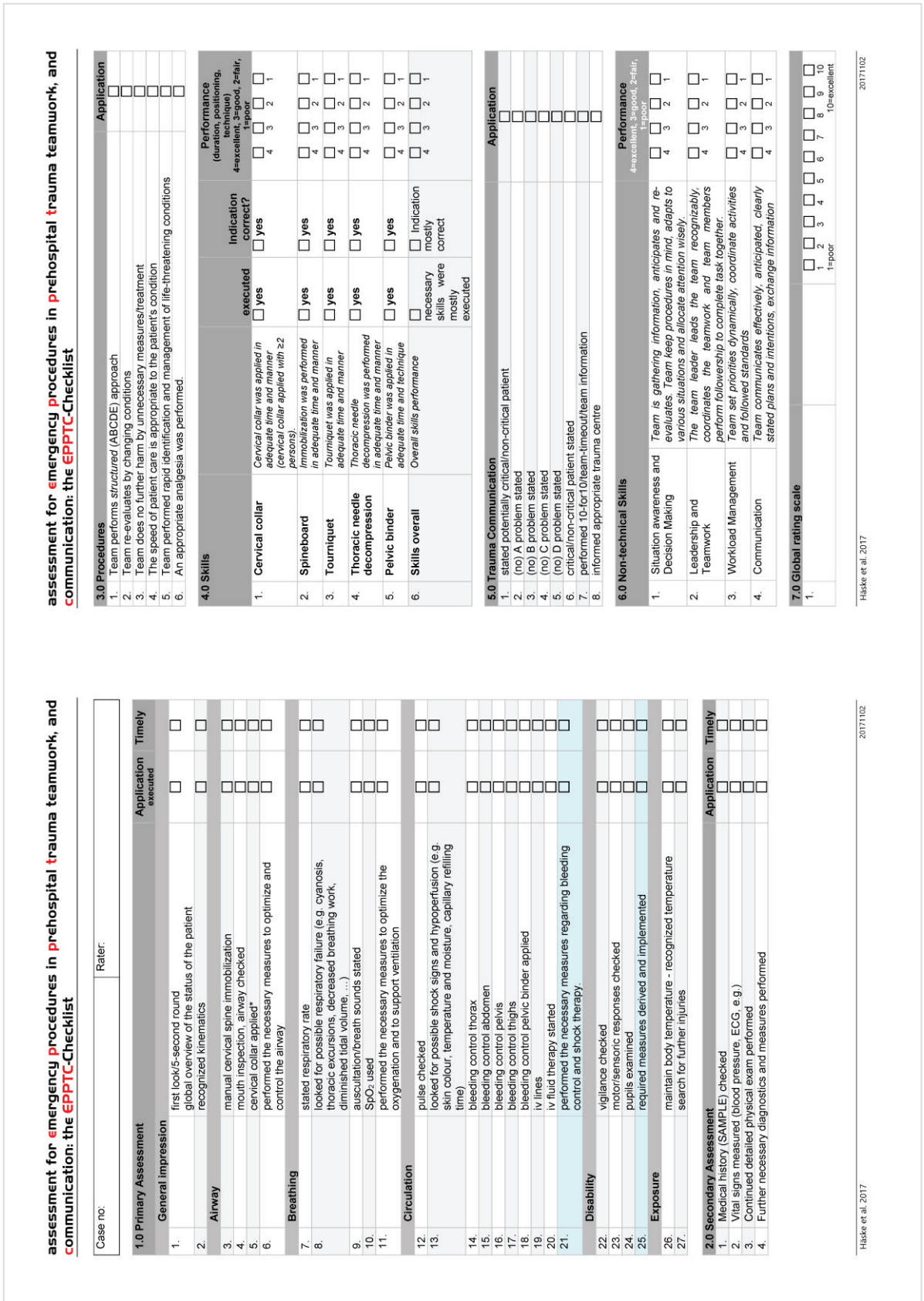
8 APPENDIX

Supplement 1: The final EPPTC checklist.



assessment for emergency procedures in prehospital trauma teamwork, and communication: the EPPTC-Checklist

Case no: | Rater:

1.0 Primary Assessment		Application executed	Timely
General impression			
1.	first look/5-second round	☐	☐
	global overview of the status of the patient		
2.	recognized kinematics	☐	☐
Airway			
3.	manual cervical spine immobilization	☐	☐
4.	mouth inspection, airway checked	☐	☐
5.	cervical collar applied*	☐	☐
6.	performed the necessary measures to optimize and control the airway	☐	☐
Breathing			
7.	stated respiratory rate	☐	☐
8.	looked for possible respiratory failure (e.g. cyanosis, thoracic excursions, decreased breathing work, diminished tidal volume, ...)	☐	☐
9.	auscultation/breath sounds stated	☐	☐
10.	SpO_2 used	☐	☐
11.	performed the necessary measures to optimize the oxygenation and to support ventilation	☐	☐
Circulation			
12.	pulse checked	☐	☐
13.	looked for possible shock signs and hypoperfusion (e.g. skin colour, temperature and moisture, capillary refilling time)	☐	☐
14.	bleeding control thorax	☐	☐
15.	bleeding control abdomen	☐	☐
16.	bleeding control pelvis	☐	☐
17.	bleeding control thighs	☐	☐
18.	bleeding control pelvic binder applied	☐	☐
19.	iv lines	☐	☐
20.	iv fluid therapy started	☐	☐
21.	performed the necessary measures regarding bleeding control and shock therapy.	☐	☐
Disability			
22.	vigilance checked	☐	☐
23.	motor/sensoric responses checked	☐	☐
24.	pupils examined	☐	☐
25.	required measures derived and implemented	☐	☐
Exposure			
26.	maintain body temperature - recognized temperature	☐	☐
27.	search for further injuries	☐	☐

2.0 Secondary Assessment		Application	Timely
1.	Medical history (SAMPLE) checked	☐	☐
2.	Vital signs measured (blood pressure, ECG, e.g.)	☐	☐
3.	Continued detailed physical exam performed	☐	☐
4.	Further necessary diagnostics and measures performed	☐	☐

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assessment for emergency procedures in prehospital trauma teamwork, and communication: the EPPTC-Checklist

3.0 Procedures		Application
1.	Team performs *structured* (ABCDE) approach	☐
2.	Team re-evaluates by changing conditions	☐
3.	Team does no further harm by unnecessary measures/treatment	☐
4.	The speed of patient care is appropriate to the patient's condition	☐
5.	Team performed rapid identification and management of life-threatening conditions	☐
6.	An appropriate analgesia was performed.	☐

4.0 Skills			executed	Indication correct?	Performance (duration, positioning, technique) 4=excellent, 3=good, 2=fair, 1=poor
1.	**Cervical collar**	*Cervical collar was applied in adequate time and manner (cervical collar applied with ≥2 persons).*	☐ yes	☐ yes	☐ 4 ☐ 3 ☐ 2 ☐ 1
2.	**Spineboard**	*Immobilization was performed in adequate time and manner*	☐ yes	☐ yes	☐ 4 ☐ 3 ☐ 2 ☐ 1
3.	**Tourniquet**	*Tourniquet was applied in adequate time and manner*	☐ yes	☐ yes	☐ 4 ☐ 3 ☐ 2 ☐ 1
4.	**Thoracic needle decompression**	*Thoracic needle decompression was performed in adequate time and manner*	☐ yes	☐ yes	☐ 4 ☐ 3 ☐ 2 ☐ 1
5.	**Pelvic binder**	*Pelvic binder was applied in adequate time and technique*	☐ yes	☐ yes	☐ 4 ☐ 3 ☐ 2 ☐ 1
6.	**Skills overall**	*Overall skills performance*	☐ necessary skills were mostly executed	☐ Indication mostly correct	☐ 4 ☐ 3 ☐ 2 ☐ 1

5.0 Trauma Communication		Application
1.	stated potentially critical/non-critical patient	☐
2.	(no) A problem stated	☐
3.	(no) B problem stated	☐
4.	(no) C problem stated	☐
5.	(no) D problem stated	☐
6.	critical/non-critical patient stated	☐
7.	performed 10-for10/team-timeout/team information	☐
8.	informed appropriate trauma centre	☐

6.0 Non-technical Skills			Performance 4=excellent, 3=good, 2=fair, 1=poor
1.	Situation awareness and Decision Making	*Team is gathering information, anticipates and re-evaluates; Team keep procedures in mind, adapts to various situations and allocate attention wisely.*	☐ 4 ☐ 3 ☐ 2 ☐ 1
2.	Leadership and Teamwork	*The team leader leads the team recognizably, coordinates the teamwork and team members perform followership to complete task together.*	☐ 4 ☐ 3 ☐ 2 ☐ 1
3.	Workload Management	*Team set priorities dynamically, coordinate activities and followed standards*	☐ 4 ☐ 3 ☐ 2 ☐ 1
4.	Communication	*Team communicates effectively, anticipated, clearly stated plans and intentions, exchange information*	☐ 4 ☐ 3 ☐ 2 ☐ 1

7.0 Global rating scale										
1.	☐ 1 1=poor	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10 10=excellent

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Supplement 2: Principal component analyses of scales

Communalities

	Initial	Extraction
Primary assessment	1.000	0.763
Secondary assessment	1.000	0.985
Procedures	1.000	0.795
Skills overall	1.000	0.985
Trauma communication	1.000	0.904
Non-technical skills	1.000	0.919
Global rating scale	1.000	0.931

Extraction method: Principal component analysis.

Total variance explained

	Initial Eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.661	66,584	66.584	4,661	66,6	66.584	3,976	56,801	56.801
2	0.988	14,108	80.692	0.988	14.1	80.692	1,190	16,999	73.800
3	0.633	9,048	89.741	0.633	9.0	89.741	1,116	15,941	89.741
4	0.336	4,805	94.546						
5	0.225	3,218	97.763						
6	0.105	1,499	99.262						
7	0.052	0.738	100.000						

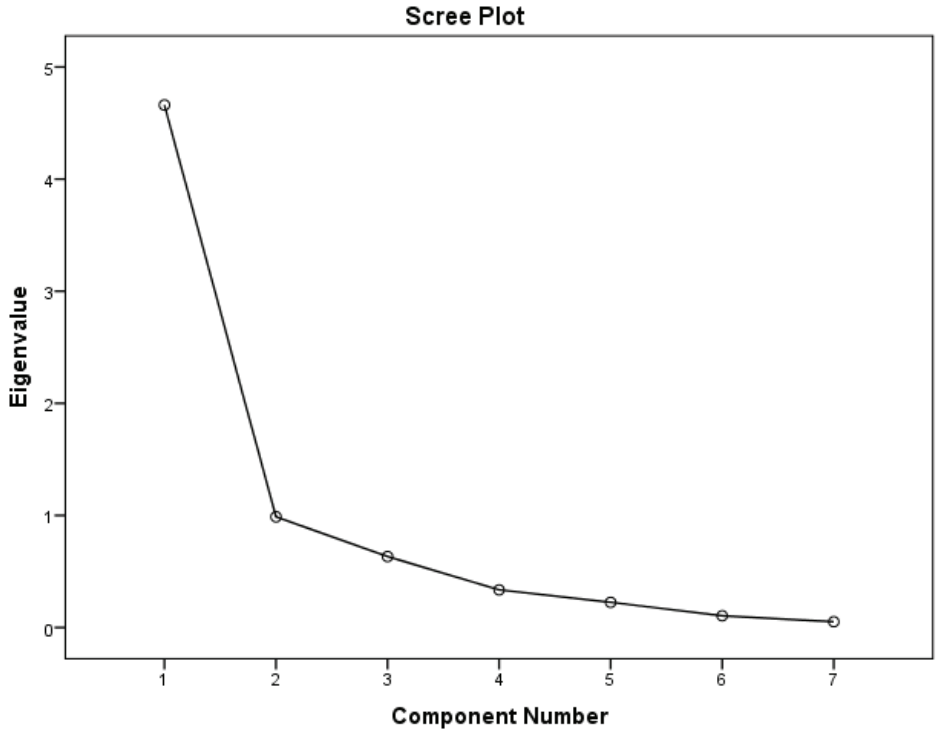
Extraction Method: Principal Component Analysis.

Rotated component matrix[a]

	Component		
	1	2	3
Primary assessment	0.827	0.282	0.004
Secondary assessment	0.119	0.106	0.979
Procedures	0.861	0.085	0.215
Skills overall	0.322	0.929	0.132
Trauma communication	0.895	0.305	-0.095
Non-technical skills	0.921	0.199	0.178
Global rating scale	0.886	0.308	0.228

Extraction method: Principal component analysis. Rotation method: Varimax with Kaiser normalisation.[a]

a. Rotation converged in 4 iterations.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3 Diskussion

Die vorliegende Studie wurde durch den Bedarf des Gesundheitsamtes Wiesbaden möglich, da dort ein kompletter Rettungsdienst und somit ein komplettes System nach einem definierten Standard geschult wurde. Die Notwendigkeit für eine tiefgreifende Schulung wurde durch den Ärztlichen Leiter Rettungsdienst der Stadt Wiesbaden gesehen (Häske et al. 2013). Man entschied sich unter anderem für das PHTLS-Konzept. Da PHTLS-Kurse für alle ca. 300 Rettungsdienstmitarbeiter mit hohen Kosten (Arbeitszeit, Kursgebühren etc.) verbunden waren, bestand von Seiten des Gesundheitsamts der berechtigte Wunsch nach einer begleitenden Untersuchung. Hiermit sollte geklärt werden, ob die Ziele, nämlich eine Verbesserung der Patientenversorgung und der Mitarbeiterzufriedenheit, erreicht wurden.

3.1 Datenerfassung und Logistik

Die Kursorganisation und Durchführung wurde von Seiten der Veranstalter übernommen. Die zweitägigen Kurse wurden ganzjährig durchgeführt, um alle 300 Angestellten auszubilden. Bei jedem Kurs wurden als Teil der vorliegenden Arbeit Videoaufnahmen der Trainings angefertigt, insgesamt ca. 300 Stück. Für die Auswertung der Einsatzdokumentation wurden zudem alle Leistungserbringer besucht, um die papierbasierte Dokumentation einzusehen und mit Hilfe des Gesundheitsamtes digital zu erfassen. Zur Untersuchung der subjektiven Veränderungen bei den Kursteilnehmern wurden ca. 800 Fragebögen verteilt und analysiert. Damit erstreckte sich alleine die reine Datenerhebung über zwei Jahre.

3.2 Übereinstimmung der PHTLS-Lehraussagen mit der S3-Polytraumaleitline 2011

Für Schulungen mit diesem Aufwand und Umfang ist von Interesse, ob die Lehrinhalte überhaupt nationalen Leitlinien und Empfehlungen entsprechen. Bei der Einführung von PHTLS hatten sich die Deutsche Gesellschaft für Unfallchirurgie (DGU) und die Deutsche Gesellschaft für Anästhesiologie und Intensivmedizin (DGAI) für das Konzept stark gemacht; PHTLS ist bis heute eines der in der S3-Polytraumaleitlinie beispielhaft empfohlenen Kurskonzepte

(Deutsche Gesellschaft für Unfallchirurgie 2008). Die Bundeswehr ebenso wie die DRF Luftrettung hatten im Laufe der Jahre PHTLS zum gängigen Standard erklärt und Personal darin schulen lassen (DRF Luftrettung 2013; Rump et al. 2014).

Um eine Vergleichbarkeit herzustellen, wurde ein internetbasiertes Scoringsystem entwickelt. Darin wurden die Kernaussagen der zum Zeitpunkt der Arbeit aktuellen S3-Leitlinie 2011 den jeweils davor analysierten Textpassagen aus dem PHTLS-Lehrbuch gegenübergestellt und konnten von den Beurteilenden in Kategorien eingeteilt werden (Tabelle 1).

Dabei wurden auch die in der Leitlinie verwendeten Empfehlungsgrade (Grade of Recommendation GoR) der Oxford Center of Evidence-Based Medicine berücksichtigt (OCEBM Levels of Evidence Working Group).

Fleiss κ lag zunächst bei 0,236 ($p < 0,001$, 95%-Konfidenzintervall 0,215 - 0,715), was einer nur mittelmäßigen Übereinstimmung entspricht (McHugh 2012). Mittels dem im Anschluss verwendeten Delphi-Verfahren konnten divergierende Aussagen geklärt werden (Häske et al. 2016).

Tabelle 1: Verwendete Kategorien zur Beurteilung der Übereinstimmung bzw. Differenzen zwischen der deutschen S3-Polytrauma-Leitlinie 2011 und dem PHTLS-Kursbuch. Quelle: (Häske et al. 2016).

Classification	Explanation
Agreement	The key recommendations of the S3 Guideline and the PHTLS manual are identical
Minor variation	Slight differences or lack of limit values between S3 Guideline and PHTLS manual
Major variation	Marked differences between S3 Guideline and PHTLS manual - clear contradiction
No statement	The PHTLS manual contains no statement on a key recommendation made in the S3 Guideline

Die letztlich hohe Übereinstimmung macht PHTLS zu einem sinnvollen Schulungskonzept. Bei der Betrachtung der divergierenden Aussagen fallen zunächst die „major variations“ ins Auge; den größten Teil machen dabei Aussagen zur Infusionstherapie aus. So empfahl die S3-Leitlinie 2011 zum

Beispiel Ringer-Malat- oder alternativ Ringer-Acetat- oder Ringer-Laktatlösung (GoR B). Ringer-Laktatlösung wird auch von PHTLS empfohlen, jedoch erwähnt PHTLS immer noch isotonische Kochsalzlösung, was zu der Bewertung "major revision" führte, da gemäß der S3-Leitlinie isotonische Kochsalzlösung nicht verwendet werden soll. Auch in der Einschätzung zur Verwendung kolloidaler Infusionen liegen die Empfehlungen auseinander. Während die S3-Leitlinie bei hypotensiven Patienten Hydroxyethylstärke 130 / 0,4 empfiehlt, spricht sich PHTLS nicht dafür aus. Auch bezüglich der Verwendung von hypertonen-hyperonkotischen Infusionen kam es zur Einschätzung "major revision", unter anderem weil die amerikanische Arzneimittelbehörde (FDA) diese nicht zugelassen hat (Häske et al. 2016).

Weitere „major variations“ gingen z.B. auf die PHTLS-Empfehlung, Etomidate zur Narkoseeinleitung zu verwenden, während die S3-Leitlinie dies explizit nicht empfiehlt und dabei auch bei hypotensiven Patienten auf Ketamin verweist. Auch die Empfehlung, bei längeren Transporten eine Blasenkatheterisierung zur Überwachung der Urinproduktion bei Schockpatienten durchzuführen, führt zu unterschiedlichen Empfehlungen (Häske et al. 2016).

Letztlich bleibt festzustellen, dass die medizinischen Empfehlungen von PHTLS auf der Einschätzung des „American College of Surgeons' Committee on Trauma“ basieren und sich allein aus der amerikanischen bzw. europäischen Perspektive unterschiedliche Empfehlungen ergeben können. Kleine Unterschiede ergeben sich beispielhaft in der Einschätzung zur Entlastungspunktion beim Pneumo- bzw. Spannungspneumothorax. Während sich beide für die Nadeldekompression im Rahmen eines „Erstangriffes“ beim Spannungspneumothorax aussprechen, empfiehlt die S3-Leitlinie eine konsekutive Anlage einer Thoraxdrainage. Diesbezüglich äußert sich PHTLS kritisch mit Verweis auf Komplikationen und Infektionen. Nur spezialisiertes Personal (z.B. Luftrettung) soll solche Maßnahmen durchführen. Aber auch im deutschen notarztunterstützten Rettungsdienst bleibt die Anlage der Thoraxdrainage selten und soll deswegen nur von gut trainiertem Personal durchgeführt werden (Häske et al. 2016; Gries et al. 2005).

Trotz der unterschiedlichen Rettungsdienstsysteme (Paramedic-System versus Notarzt-gestütztes System) ist auf der anderen Seite die Übereinstimmung bemerkenswert, gerade weil auch die Ausbildung des Rettungsfachpersonals in Deutschland und den USA unterschiedlich aufgebaut ist. Während die amerikanischen Paramedics in der Ausbildung sehr viel Fertigkeiten trainieren, wird in der Rettungsassistenten- bzw. Notfallsanitäter-Ausbildung in Deutschland deutlich mehr theoretisches Wissen vermittelt. Daher sind die amerikanischen Kurse wiederum theorielastiger, während die europäischen PHTLS-Kurse, auch auf Wunsch der ärztlichen/nicht-ärztlichen Teilnehmer, einen deutlich größeren Anteil an Fertigkeits- und Szenariotrainings beinhalten.

3.3 Subjektive Sicherheit, Selbstvertrauen und Lernverhalten

Die Ergebnisse der Befragung zeigen zunächst, dass die Erwartungen der Teilnehmer auch nach einem Jahr erfüllt wurden (Häske et al. 2017b). Dieses Ergebnis war im Rahmen der vorliegende Studie nicht unwichtig, da der Grund für die Einführung von PHTLS neben dem Eindruck sich verschlechternder Patientenversorgung auch die Unzufriedenheit der Mitarbeiter hinsichtlich der damaligen Fortbildungen war (Häske et al. 2013).

Die Frage, ob die Teilnehmer ihr Wissen zu traumatologischen Notfällen erweitern konnten, wurde zwar jeweils bejaht, aber direkt nach dem Kurs mit Median 7 bewertet und nach einem Jahr signifikant schlechter mit Median 6 ($p = 0{,}003$). Dass sich Wissen schnell verflüchtigen kann, ist nicht unbekannt (Friederichs et al. 2016) und könnte auch in diesem Fall zutreffen, so dass bestimmte Lehrinhalte bereits nach einem Jahr in Vergessenheit geraten sind (Häske et al. 2017b).

Mohammad et al. analysierten in einem systematischen Review die pädagogischen und klinischen Effekte von ATLS-Kursen (Mohammad et al. 2014). Sie zeigten, dass sich Wissen, Fertigkeiten und der prioritätenbasierte Ansatz durch Training zunächst verbessern. Jedoch nach einem halben Jahr nehmen Wissen und Fertigkeiten bereits wieder ab, im Gegensatz zum prioritätenbasierten Ansatz. Die Autoren führen weiter aus, dass nach wie vor

starke Beweise hinsichtlich einer Reduktion von Morbidität und Mortalität für ATLS-Kurse fehlen (Mohammad et al. 2014).

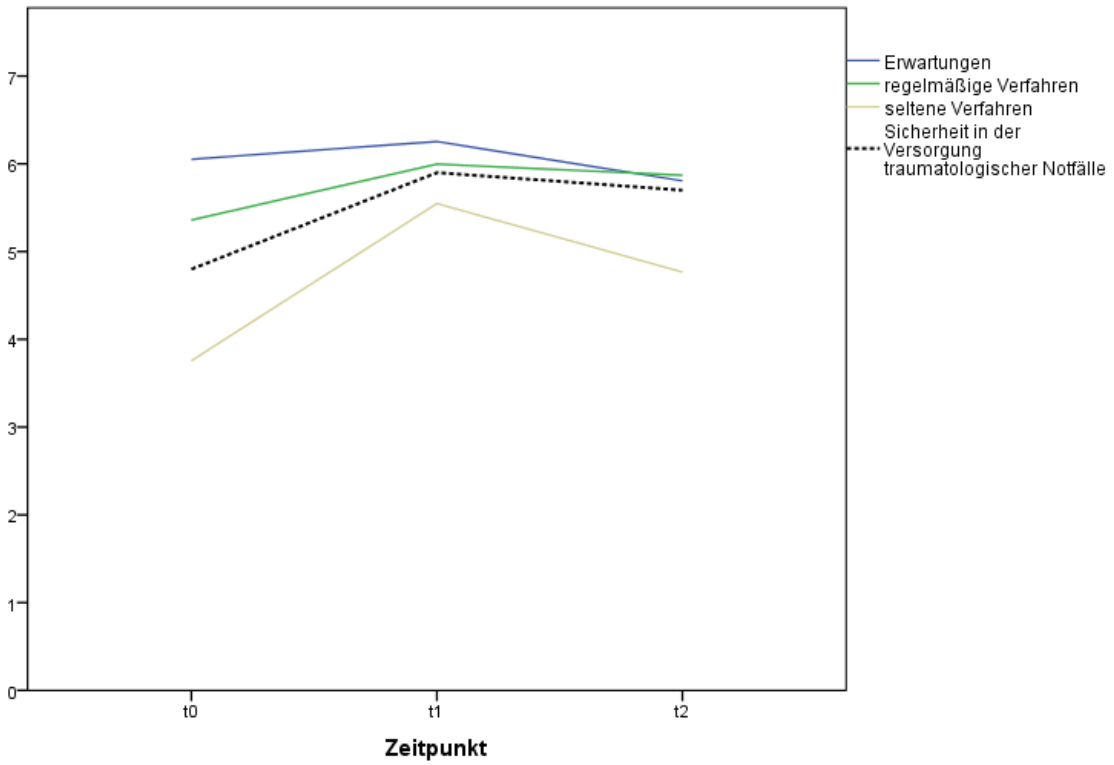

Abbildung 2: Die Abbildung zeigt die nach Faktoren (1, 2, 4) zusammengefassten Mittelwerte. Zusätzlich ist das Item „Sicherheit bei der Versorgung traumatologischer Notfälle“ inkludiert. Die x-Achse zeigt die drei Messpunkte, die y-Achse die Ausprägungen des Fragebogens. Quelle: (Häske et al. 2017b)

In unserer Befragung war die zentrale Frage die nach der subjektiven Sicherheit in der Versorgung traumatologischer Patienten. Dabei war zum Messzeitpunkt direkt nach dem Kurs (t1) und ebenso ein Jahr nach dem Kurs (t2) die Sicherheit signifikant höher als vor dem Kurs (t0: 4,8 ± 1,0; t1: 5,9 ± 0,7; t2: 5,7 ± 0,8, $p<0,001$) (Häske et al. 2017b).

Die zugehörige lineare Regressionsanalyse zeigte, dass zum einen die Verwendung der geschulten prioritätenbasierten Versorgungsstruktur und zum anderen die Sicherheit in allen Fertigkeiten signifikant zur Sicherheit in der Versorgung traumatologischer Notfälle führte (Tabelle 2).

Im Unterschied zur Untersuchung von Tsugawa et al. zum Einfluss des Alters des Behandlers auf die Mortalität, zeigte die vorliegende Untersuchung nach der

Schulung bei der subjektiven Einschätzung keinen Einfluss des Alters respektive der Berufserfahrung auf die Sicherheit (Häske et al. 2017b; Tsugawa et al. 2017).

Tabelle 2: Modifizierte Darstellung der signifikanten Prädiktoren der linearen Regressionsanalyse. SE = standard error, 95%-KI = 95%-Konfidenzintervall. Quelle: (Häske et al. 2017b)

Prädiktor	Koeffizient (SE)	95%-KI	p-Wert
Verwendung der ABCDE-Untersuchungs- und Versorgungstruktur	0,09 (0,04)	0,01–0,18	0,036
Beispiel seltene Maßnahmen	0,10 (0,03)	0,05–0,15	<0,001
Beispiel häufige Maßnahme	0,43 (0,05)	0,33–0,53	<0,001

Wie weit subjektive Einschätzung und objektive Tatsache auseinander liegen können, konnten auch Kreinest et al. mit Untersuchungen zur Immobilisation der Halswirbelsäule zeigen (Kreinest et al. 2015): Selbsteinschätzung und korrekte Fertigkeit lagen reziprok auseinander. 84% der Studienteilnehmer waren zwar mit der Anlage einer Zervikalstütze sehr vertraut, doch nur 11% davon legten sie fehlerfrei an (Kreinest et al. 2015).

3.4 Leistungsbeurteilung von Notfallteams und Kommunikation in der Traumaversorgung. Entwicklung und Validierung einer Checkliste

Subjektive Veränderungen alleine erklären nur ungenügend systemische Effekte im Sinne der vorliegenden Forschungsfrage. Zu diesem Zwecke wurden Videoaufnahmen von szenariobasierten Traumaversorgungen hinsichtlich der Veränderung der Teamleistung zu den drei Messpunkten t0, t1 und t2 zu evaluieren. Dazu wurde ein zuverlässiges und valides Messinstrument benötigt, welches eine Vergleichbarkeit der Teamleistung (Performance) – ähnlich einem OSCE – zulässt. Bestehen Assessmenttools waren jedoch für vorliegende Zwecke ungeeignet (Häske et al. 2018). Deswegen wurde die „Performance Assessment of Emergency Teams and Communication in Trauma Care“ (PERFECT-Checklist) entwickelt und validiert (Häske et al. 2018). Ziel war es, basierend auf einem Summenscore die Evaluationen von Trainings oder realer Patientenversorgung vergleichbar zu machen. Amateurschauspieler simulierten schwerverletzte Patienten mit führender schweren Thoraxverletzung und dislozierten Sprunggelenkfrakturen, jedoch immer mit unterschiedlichen

Ursachen und Situationen. Verletzungen sollten einem Injury Severity Score (ISS) von ca. 38 (abbreviated injury scale (AIS): AIS 0-0-5-2-3-1) entsprechen.

3.4.1 Explorative Analyse der Videodaten

Für die Entwicklung der Checkliste wurden zunächst in einer explorativen Analyse Videoaufnahmen gesichtet, um einen Eindruck des vorhandenen Datenmaterials zu bekommen.

Die zeitliche Analyse der Durchführung von Maßnahmen entsprechend der ATLS/PHTLS-Konzepten zeigte, dass mehrheitlich die Maßnahmen zum Messpunkt t1 und t2 früher als zum Messpunkt t0 durchgeführt wurden und das Konfidenzintervall meist enger wurde (Häske et al. 2018). Die zugehörige Abbildung 3 zeigt eine klar erkennbare Fokussierung auf Airway, Breathing, Circulation und damit auf die lebensrettenden Maßnahmen.

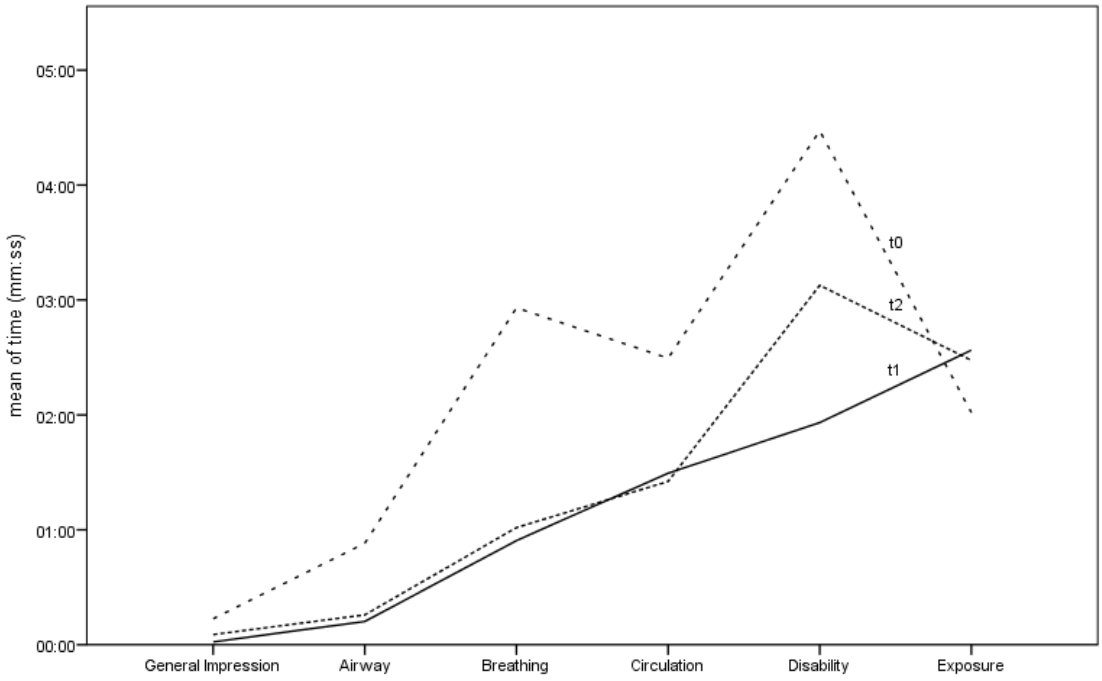

Abbildung 3: Die Abbildung zeigt den durchschnittlichen Beginn der Maßnahmen in der initialen Herangehensweise (ABCDE/primary assessment), gruppiert nach den drei verschiedenen Messpunkten. T1 passt am besten zum (linearen) ABCDE-Ansatz, gefolgt vom Graphen t2. T0 hat die größte Abweichung von t1. Quelle: (Häske et al. 2018)

Im Rahmen der explorativen Analyse wurde nach Merkmalen gesucht, welche die subjektive Sicherheit der Teilnehmer erklären oder reziprok eine Veränderung

von Stress erkennen lassen. Bekannt ist, dass der präfrontale Kortex normalerweise für Prozessabläufe und logisches Denken verantwortlich ist, was unter Stress jedoch nur noch eingeschränkt möglich ist (Ungerer und Morgenroth 2001). Darauf basierend wurde bereits in den 1990ern die Cockpit-Kommunikation der Luftfahrt bezüglich Sprache, Fehler und Arbeitsbelastung analysiert (Sexton und Helmreich 2000). Gerade unter zunehmendem Stress nimmt die Merkfähigkeit des Gehirns auf wenige Sekunde ab (Vetter et al. 2015). Die Übertragbarkeit dieser Erkenntnisse auf die Akutmedizin ist weitverbreitet und anerkannt (Doepfer et al. 2017; Rall und Gaba 2009a).

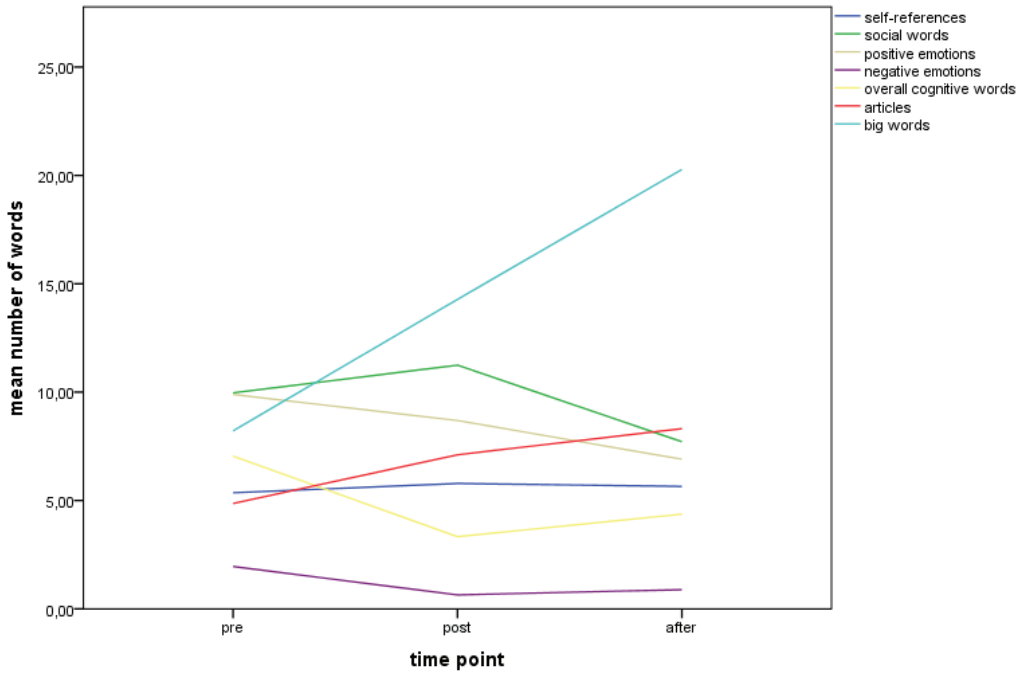

Abbildung 4: linguistische Analyse der Kommunikation des Teamleaders zu den drei Messpunkten t0, t1, t2. Die Zunahme der langen Wörter und Artikel ist offensichtlich während kognitive und emotionale, ebenso wie emotionale Wörter abnehmen (Quelle: (Häske et al. 2018)).

Die vorliegende linguistische Analyse der Kommunikation des Teamleiters mit dem Team zeigte ein verändertes Kommunikationsverhalten von Messpunkt zu Messpunkt (Abbildung 4). Offensichtlich ist die Veränderung der Zunahme großer Wörter und Artikel, während die kognitiven und sozialen Wörter sowie die Emotionen abnehmen.

Betrachtet man beispielhaft die langen Wörter und Verwendung von Artikeln als Surrogat-Endpunkt für Stress, so scheint die Zunahme der Wörter in beiden Kategorien diametral für eine Abnahme von Stress zu sprechen. Dies wiederum würde mit dem Ergebnis zur subjektiven Sicherheit korrelieren und diese Einschätzung unterstreichen, da Struktur in der Patientenversorgung die subjektive Sicherheit erhöht (Häske et al. 2017b). Für belastbare Ergebnisse steht jedoch eine induktive Statistik aus.

Im Rahmen der semi-qualitativen Analyse wurden schließlich 84 Codes generiert. Die Anzahl der Codes gaben zwar differenziertes Bild der Szenarien, waren jedoch zu komplex, um sie während des Trainings oder möglicherweise während der Patientenversorgung in einer Checkliste zu verwenden. Während des Delphi-Prozesses des Expertenpanels wurden die Codes auf die für die Checkliste geeigneten Elemente reduziert und dabei in Anlehnung an die qualitative Inhaltsanalyse nach Mayring die Codes geclustert und daraus (klinisch) relevante Items generiert (Mayring 2003). Ein Beispiel zum Punkt „Breathing“ in der ABCDE-Versorgungsstruktur ist in Abbildung 5 zu sehen.

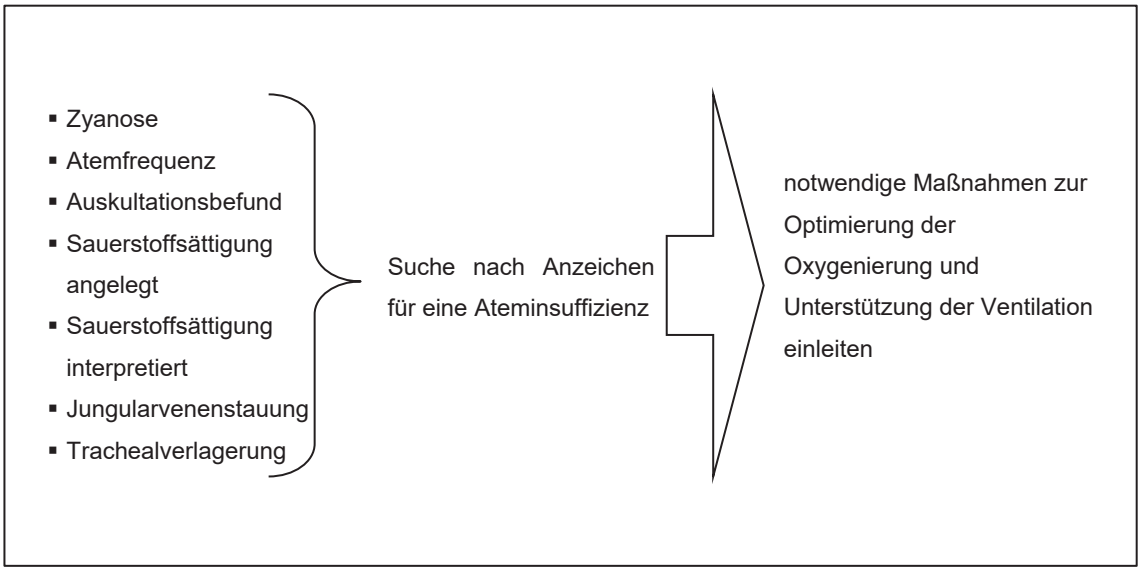

Abbildung 5: Beispiel „Breathing“ in der ABCDE-Struktur. Einzelne Codes werden nach klinisch relevanten Gruppen zusammengefasst und die zugehörigen Maßnahmen angehängt.

3.4.2 Skalen

Die Videoanalyse zeigte auch, dass einige Teams zwar alle Punkte auf der Checkliste erreichten, aber weder in der adäquaten Zeit, noch strukturiert oder mit dem erkennbaren Fokus auf ein schnelles Identifizieren von lebensbedrohlichen Befunden und der Einleitung rettender Maßnahmen. Da bereits bekannt war, dass eine strukturierte Patientenbehandlung einen signifikanten Einfluss auf die subjektive Sicherheit in der Traumaversorgung hat (Häske et al. 2017b), wurde in der Skala „Procedures“ die relevanten Faktoren wie z.B. schnelles Erkennung und Behandlung von lebensbedrohlichen Zuständen, strukturierte Herangehensweise, Tempo, Vermeidung unnötiger Maßnahmen aufgenommen.

In der qualitativen Analyse waren deutliche Unterschiede in den nicht-technischen Fertigkeiten (NTS) festzustellen. Für die NTS-Skala in der Checkliste wurde eine 4-Punkte-Skala verwendet, welche inhaltlich mit der relevanten Literatur abgeglichen wurde (Rall und Gaba 2009a; Doepfer et al. 2017).

Wallin et al. hatten den Einfluss von Teamtraining bei Medizinstudenten untersucht und konnten dabei eine Verbesserung der klinischen Fertigkeiten nachweisen, jedoch nicht in der Teamarbeit (Wallin et al. 2007). Dahingegen konnten wir eine deutliche Verbesserung der Teamarbeit und Teamperformance sehen, jedoch müssen diese Ergebnisse noch mit adäquaten Fallzahlen bestätigt werden (Häske et al. 2018).

Die größte und abschließend nicht gelöste Herausforderung war die differenzierte Beurteilung von technischen Fertigkeiten. Dies betrifft sowohl die individuelle Beurteilung hinsichtlich Durchführung, Indikationsstellung, Qualität der Ausführung, sowie die Integration in das Punktsystem der Checkliste. Die Schwierigkeit war die Berücksichtigung variablen Anzahl von Fertigkeiten. Zum Beispiel könnte ein Szenario mit drei Fertigkeiten theoretisch einen dreifachen „Skillwert“ erhalten, während ein anderes Szenario mit nur einer Fertigkeit sehr gut ausgeführt werden könnte, aber automatisch weniger auf der einen Fertigkeit erzielt hätte. Um die Checkliste praktikabel zu halten, viel der Entschluss lediglich

ein Item „Skill overall“ stellvertretend für andere Fertigkeiten in die Berechnung aufzunehmen.

Basierend auf den positiven Erfahrungen von Dankbaar et al., wurde ebenfalls eine „Global Performance Scale“ genutzt, um der Erfahrung der Rater gerecht zu werden (Dankbaar et al. 2014). Dabei ist es aber wichtig, gut geschulte Anwender der Checkliste zu haben.

Die unterschiedliche Codierung der Skalen wurde auch in der Arbeitsgruppe diskutiert. Für die klassische OSCE werden häufig binäre Codes verwendet, welche aber als gleichwertig mit mehrstufigen Bewertung gelten (Nikendei und Jünger 2006). Häufig werden für die Beurteilung technischer Fertigkeiten eher binäre Bewertungsskalen genutzt, als bei der Beurteilung von Kommunikation (Newble 2004). Auch die Punktzahl bzw. Spannweite von solchen Bewertungsskalen variiert erheblich (Cooper et al. 2010; Parker-Raley et al. 2013; Steinemann et al. 2012). Im vorliegenden Fall wurde die binäre Codierung für die Maßnahmen und Verfahren verwendet. 4-Punkte-Bewertungsskalen wurde für Fertigkeiten verwendet, während die „Global Ratingscale“ dagegen eine 6-Punkte-Ratingskala hatte.

3.4.3 Validität und Reliabilität

Für die Entwicklung der Checkliste wurde eine Möglichkeit gesucht, nicht nur den quantitativen bzw. qualitativen Zuwachs von Einzelmaßnahmen darzustellen, sondern eine allgemeine Bewertung von Notfallversorgungen bei Trauma-Patienten vorzunehmen. Die Grundidee war mit Hilfe eines Summenscores eine Vergleichbarkeit herzustellen. Die PERFECT-Checkliste zeigte eine sehr gute Reliabilität und Validität

Die Grundanforderungen an Tests, respektive Messverfahren zeigen sich in den Gütekriterien Validität, Reliabilität und Objektivität. Bortz & Böring formulieren dazu: „*Ein Test ist konstruktvalide, wenn aus dem zu messenden Zielkonstrukt Hypothesen ableitbar sind, die anhand der Testwerte bestätigt werden können.“* (Bortz und Döring 2009). Empfehlungen zur Messung der Validität teilen sich dabei auf, zum Beispiel in die Inhaltsvalidität, Konstruktvalidität und

prognostische und diagnostische Kriteriumsvalidität (American Psychological Association, American Educational Research Association, & National Council on Measurement in Education 1954).

Die Inhaltsvalidität wird in aller Regel durch Experten bestimmt. Zumeist wird die Inhaltsvalidität im Konsens eines Expertenpanels oder mittels Delphi-Verfahren bestimmt, jedoch besteht auch die Möglichkeit einen Content-Validity-Index (CVI) zu berechnen (Cooper et al. 2010). Da die Inhaltsvalidität trotz Absicherung einer gewissen Subjektivität der Experten unterliegt, wird die Inhaltsvalidität von anderen Autoren auch in ihrer Wertigkeit als Testgütekriterium kritisch gesehen (Bortz und Döring 2009). Im Kontext der vorliegenden Studie wurde deswegen auf die Berechnung eines CVI verzichtet, zumal die Expertise der Beurteiler als relevanter erachtet wurde. So erfolgte eine Abstimmung und Ausgestaltung im Delphi-Verfahren.

Für die Bestimmung der Konstruktvalidität wurde eine Faktorenanalyse durchgeführt. Die drei detektierten Faktoren (Eigenwert ≥ 0,5) konnten 89,7 % der gesamten Varianz erklären. Dabei korreliert die Faktorenbildung mit der unserer Einschätzung, dass insbesondere das sogenannte Primary Assessment (ABCDE), die Procedures, die Trauma Communication, die non-technical skills und die Global Performance Scale den größten Teil der Ergebnisse erklären.

Für die Übereinstimmungsvalidität ist die Höhe der Korrelationen relevant. Wenn verfügbar, werden dabei validierte Tests herangezogen. Wenn wie im vorliegenden Fall jedoch kein passendes Testkriterium zur Verfügung steht, kann man die einzelnen Skalen korrelieren (Tabelle 3).

Tabelle 3: Konstruktvalidität: * bedeutet $p < 0,001$, für zweiseitige Tests. Nicht-technische Fertigkeiten und die Global performance scale zeigen die höchste Korrelation (r=0,930), gefolgt von nicht-technischen Fertigkeiten und Procedures (r=0,825). Quelle (Häske et al. 2018).

	Primary assessment	**Procedures**	**Non-technical skills**	**Global performance scale**
Primary assessment	-			
Procedures	0,654*	-		
Non-technical skills	0,745*	0,825*	-	
Global performance scale	0,806*	0,774*	0,930*	-

3.4.4 Inter-rater Reliabilität

Inter-rater Reliabilität mittels Intraklassencorrelation (ICC) zeigte eine sehr gute Gesamtübereinstimmung mit ICC = 0,993 und ist dabei deutlich höher als die ICC vergleichbarer Assessment-Tools (0,6-0,8) (Cooper et al. 2010; DeMoor et al. 2017; Steinemann et al. 2012), als auch die Übereinstimmung bei den spezifischen Skalen.

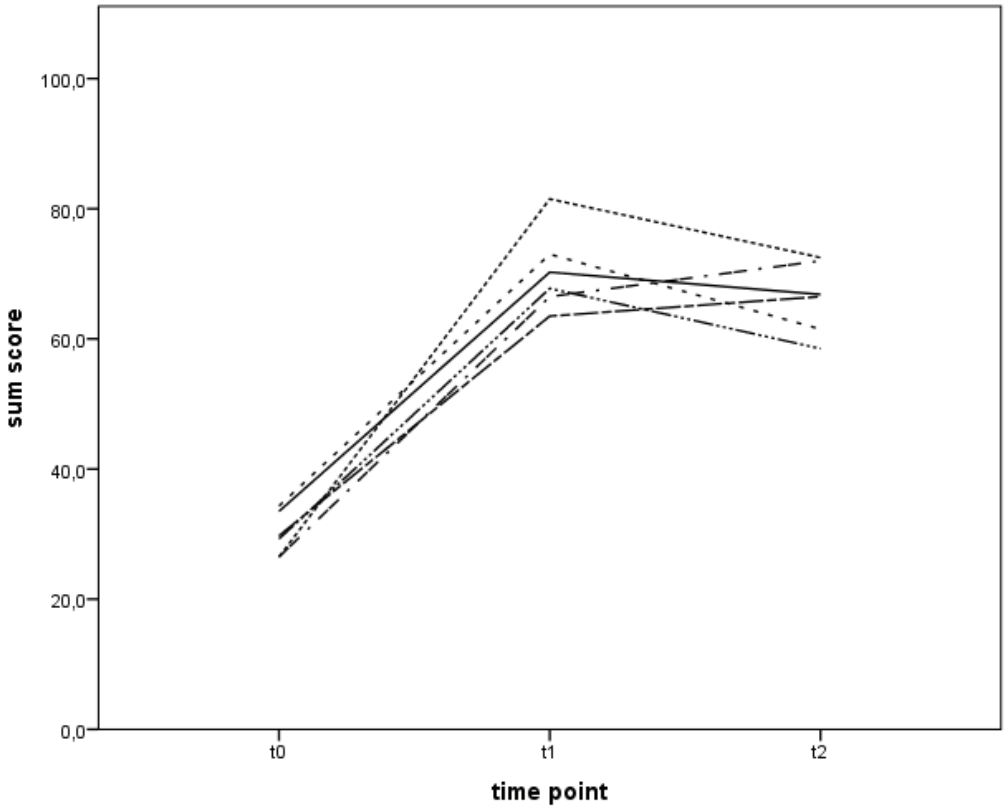

Abbildung 6: Diese Abbildung zeigt die hohe Inter-Rater-Übereinstimmung (ICC = 0,993) der sechs Bewerter und deren Bewertung an verschiedenen Messpunkten. Die Auswertung der Gutachter zeigt eine deutlich bessere Leistung der Teams nach dem Kurs als zuvor, jedoch mit einer leichten Verschlechterung von unmittelbar nach dem Kurs auf ein Jahr später. Quelle: (Häske et al. 2018).

3.5 Dokumentationsqualität als Surrogat-Parameter für Aufmerksamkeit und Trainingseffektivität

Eine weitverbreitete objektivierbare Überprüfung von Wissen ist der pre/post-Vergleich von Schulungen. Auch Ali et al. zeigten damit einen guten Lernerfolg von PHTLS-Kursteilnehmern (Ali et al. 1998a).

In vorliegender Studie war jedoch die Überlegung, wie Effekte der Schulung in der realen Patientenversorgung ermittelt werden können, was mit einer schriftlichen Prüfung alleine nicht möglich wäre. Dazu wurde die Dokumentationsqualität realer prähospitaler Notfalleinsätze als Surrogat-Endpunkt für die Effektivität der Schulung zu verwenden.

Im sogenannten „secondary assessment“ (survey) entsprechend PHTLS/ATLS, werden weiterführende Diagnostik und Anamnese erhoben. Als hinsichtlich der Patientensicherheit relevante anamnestische Informationen werden insbesondere die Fragen nach Allergien, Vorgeschichte/Vorerkrankung und Medikation angesehen (NAEMT 2012). Gerade diese Items wurden auch als Surrogat-Endpunkte in der vorliegenden Analyse genutzt. Dabei ist ein Zuwachs an Informationen im pre/post-Vergleich der Schulung um + 47,2 % bei den Allergien, + 38,1 % bei der Medikation und + 27,8 % bei den Vorerkrankungen ($p < 0,001$) zu verzeichnen (Häske et al. 2017a).

Dabei waren die Schweregrade der Erkrankungen und Verletzungen in beiden Jahren basierend auf dem RMC (Rückmeldecode) gleichverteilt (beide Jahre 8 ± 2) (Arntz und Kreimeier 2010). Der RMC hat mindestens 6 Punkte und erreicht maximal 42, so dass davon abgeleitet, Patienten nicht sehr schwer verletzt bzw. erkrankt waren, was einer typischen großstädtischen Einsatzverteilung entspricht.

Die Steigerung der Informationen nach Schulung darf jedoch nicht darüber hinwegtäuschen, dass trotzdem in 24,4 % der Einsätze die Dokumentationsqualität verbessert werden könnte. Gerade an den Schnittstellen der Patientenversorgung (z.B. Schockraum) kommt es regelmäßig zu Informationsverlusten (Enke 2009), was letztlich insbesondere Ergebnisse und Befunde der körperlichen Untersuchung als auch Anamnese betrifft (Schiff et al. 2009). Bergrath et al. zeigten in einer videobasierten Fehleranalyse das in der Einsatzdokumentation von Notärzten nach Simulationstrainings 20% der gewonnenen Informationen fehlten und 22% der dokumentierten Informationen falsch waren.

Viel hängt schlicht und ergreifend von der nötigen Aufmerksamkeit ab. Dabei ist Aufmerksamkeit (Awareness) und das Lenken von Aufmerksamkeit ein elementarer Bestandteil von nicht-technischen Fertigkeiten, welcher insbesondere alle „High-Perfomance-Teams“ auszeichnet (Westli et al. 2010).

Die vorliegenden Ergebnisse zeigen wiederum, dass zum Teil mit einfachen Trainings die Aufmerksamkeit erhöht werden kann (Häske et al. 2017a).

3.6 Schlussfolgerung

Die vorliegende Arbeit zeigt, dass für eine systematische Verbesserung der Patientenversorgung ein komplexer methodischer Ansatz gewählt werden muss, welcher wie Søreide et al. postuliert, zunächst die medizinische Wissenschaft und Leitlinien-Entwicklung, die Lehre und Ausbildung, sowie die lokale Umsetzung erfordert (Søreide et al. 2013). Für diese Zwecke wurde ein internationales Trainingskonzept zur Verbesserung der prähospitalen Versorgung von Traumapatienten ausgewählt, welches in hohem Maße mit den Empfehlungen der deutschen Polytrauma-Leitlinie korreliert. Die Erfolge der Schulungs- und Trainingsmethoden lassen sich sowohl an objektiven Kriterien wie der Dokumentationsqualität ableiten als auch in longitudinalen Analysen. Dabei konnte eine Steigerung der subjektiven Sicherheit in der Versorgung von Traumapatienten bestätigt werden, für die Struktur in der Patientenversorgung als auch Sicherheit in den Fertigkeiten relevant ist. Die Entwicklung einer zugehörigen Checkliste zur objektiven Überprüfung von Trainingsszenarien ergibt eine hohe Reliabilität und Validität, welche in ersten explorativen Analysen eine Verbesserung der Teamperformance und reduziertes Stresslevel darlegt.

Damit ist es nun möglich große Fallzahlen zu untersuchen und so den konkreten Einfluss auf die reale Patientenversorgung zu untersuchen und optimieren. Denn diese soll nach wie vor im Mittelpunkt aller Bemühungen stehen.

4 Zusammenfassung

Ziel der Arbeit war es in einer prospektiven, longitudinalen mixed-methods Studie die objektiven und subjektiven Veränderungen der Teilnehmer von Teamtraining am Beispiel von Pre-Hospital Trauma Life Support (PHTLS)-Kursen zu untersuchen. Dazu wurden Teamtrainings von 300 Rettungsassistenten evaluiert. Messungen wurden direkt vor dem Kurs (t0), direkt nach dem Kurs (t1) und ein Jahr nach dem Kurs (t2) durchgeführt.

Die Lehraussagen von PHTLS als präklinisches Pendant zum ATLS-Schockraum-Management wurden auf Übereinstimmung mit der S3-Polytrauma-Leitlinie der DGU mittels Rating-System und Delphi-Verfahren überprüft. Um den Einfluss der Trainings auf die subjektive Sicherheit zu evaluieren, wurden Fragebogen für alle drei Messpunkte entwickelt und ausgewertet. Zur Erfassung der objektiven Veränderungen wurden Videos von 300 Teamtrainings aufgenommen. Dazu wurde nach einer explorativen Analyse mit semi-qualitativer / linguistischer Analyse eine Checkliste als Messinstrument zur Beurteilung der Videos entwickelt und auf Validität und Reliabilität getestet. Um die Effektivität des Trainings zu bewerten, wurde die Dokumentationsqualität vor und nach den Kursen als Surrogat-Endpunkt verwendet.

Die Lehraussagen von PHTLS und die Kernaussagen der S3-Polytraumaleitlinie DGU stimmen in 88 % weitestgehend überein. Die 12 % abweichenden Aussagen betreffen hauptsächlich die Infusionstherapieschemata. In 236 Datensätzen der Fragebogen konnte gezeigt werden, dass die Erwartungen der Teilnehmer des Kurses voll erfüllt wurden ($p = 0{,}002$). Die subjektive Sicherheit in der Traumaversorgung war in der longitudinalen Analyse signifikant besser ($p < 0{,}001$). Struktur in der Versorgung war hierfür entscheidend ($p = 0{,}036$), ebenso wie die Sicherheit bei seltenen und häufigen Fertigkeiten ($p < 0{,}001$). Lediglich Wissen und spezifische Sicherheit nahmen nach einem Jahr ab. Aus den Videos wurde zunächst die „Performance Assessment of Emergency Teams and Communication in Trauma Care“-(PERFECT) Checklist zur Beurteilung der Aufnahmen entwickelt. Die Inter-Rater-Reliabilität (ICC = 0,99) und die interne Konsistenz ($\alpha = 0{,}99$) waren hoch. Die Übereinstimmungsvalidität war moderat

bis hoch (r = 0,65 - 0,93, p < 0,001). Die Prozesse wurden im Mittel über die Zeitachse schneller durchgeführt (t0: 2:29, 95 % KI 1:54-3:03 min., t1: 1:11, 95 % KI 0:53-1:30 min, t2: 1:14, 95 % KI 0:56-1:31 min.). Alle Experten bewerteten die aufgezeichneten Szenarien zu t0 mit dem niedrigsten Summenwert (Mittelwert 31 ± 8) und zu t1 mit einer deutlich besseren Leistung der Teams (Mittelwert 69 ± 7). Die Leistung bei t2 (Mittelwert 66 ± 13) war geringfügig schlechter als bei t1, aber immer noch deutlich besser als bei t0. Zu t1 und t2 zeigte die linguistische Analyse eine Veränderung des Kommunikationsverhaltens der Teamleiter, was als Surrogat-Parameter für reduzierten Stress interpretiert werden kann und unseren Analysen zur subjektiven Sicherheit entspricht. 640 analysierte Einsatzprotokolle zeigen, dass die Schulung zu einem signifikanten Anstieg der Dokumentationsqualität (p < 0,001) führt. Die Untergruppenanalyse von "Allergien" (+ 47,2 %), "Dauermedikation" (+ 38,1 %) und "Anamnese" (+ 27,8 %) vor und nach dem PHTLS-Kurs zeigten eine signifikante Zunahme der Information.

Die Untersuchungen zeigten eine hohe Übereinstimmung der Lehraussagen von PHTLS mit der S3-Polytraumaleitlinie und damit eine gute Anwendbarkeit der Schulungen als Trainingskonzept in Deutschland. Hinsichtlich der subjektiven Sicherheit konnte die signifikante Steigerung auch in der longitudinalen Analyse gezeigt und die Bedeutung von ausreichendem Training der Fertigkeiten und die Bedeutung Schulung von Struktur in der Patientenversorgung demonstriert werden. Für die objektive Beurteilung von Trainingseffekten wurde die PERFECT-Checkliste mit hoher Reliabilität und Validität entwickelt, welche in ersten Analysen eine objektive Verbesserung der Versorgung traumatologischer Simulationspatienten darlegt. Der verbesserte Surrogat-Endpunkt Dokumentationsqualität in der Einsatzdokumentation bestätigt als Indikator ein effektives Training und eine Sensibilisierung der Teilnehmer.

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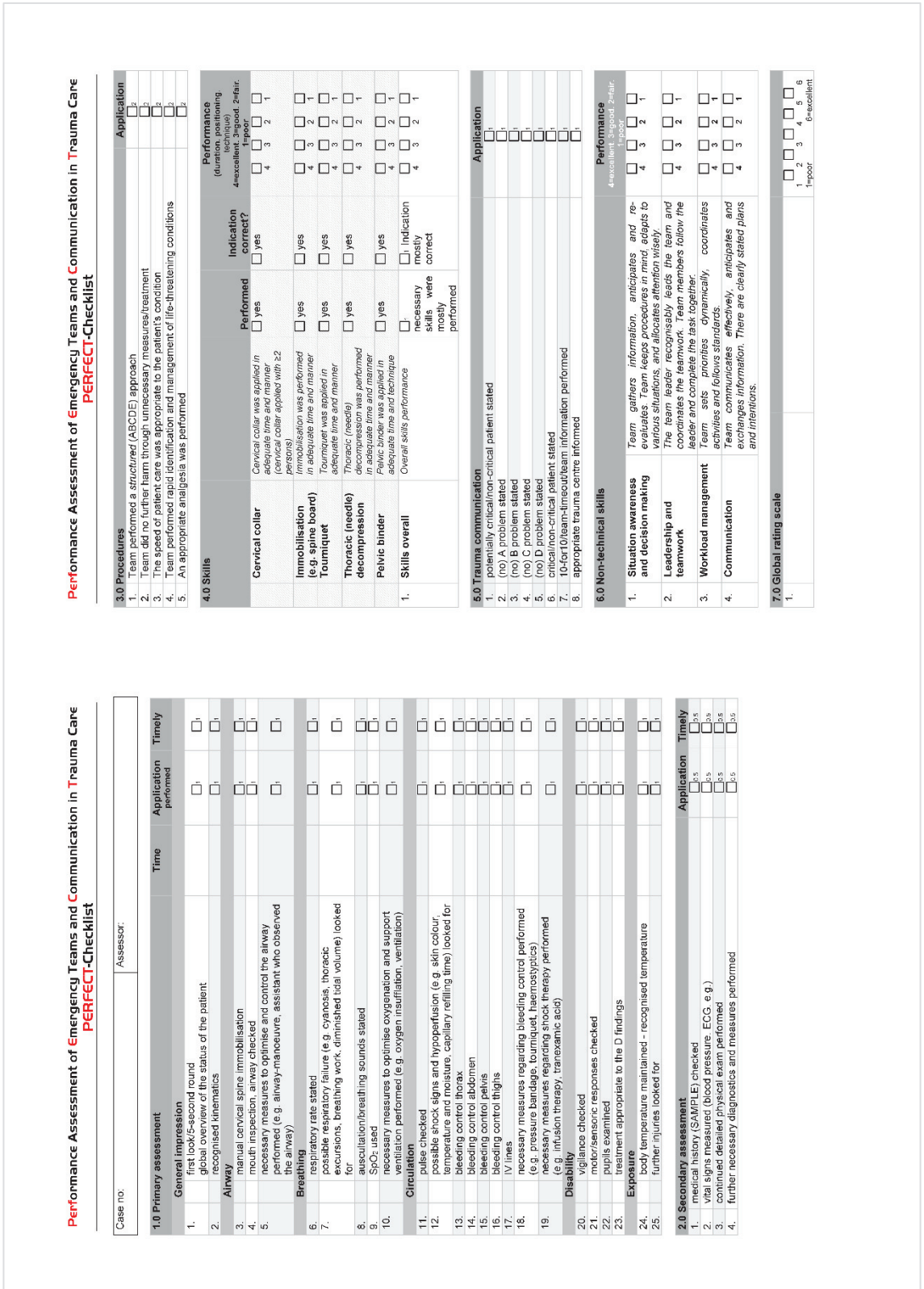
6 Anhang



Performance Assessment of Emergency Teams and Communication in Trauma Care
PERFECT-Checklist

Case no. | Assessor:

1.0 Primary assessment	Time	Application performed	Timely
General impression			
1. first look/5-second round		☐1	☐1
2. global overview of the status of the patient		☐1	☐1
2. recognised kinematics			
Airway			
3. manual cervical spine immobilisation		☐1	☐1
4. mouth inspection, airway checked		☐1	☐1
5. necessary measures to optimise and control the airway performed (e.g. airway-manoeuvre, assistant who observed the airway)		☐1	☐1
Breathing			
6. respiratory rate stated		☐1	☐1
7. possible respiratory failure (e.g. cyanosis, thoracic excursions, breathing work, diminished tidal volume) looked for		☐1	☐1
8. auscultation/breathing sounds stated		☐1	☐1
9. SpO_2 used		☐1	☐1
10. necessary measures to optimise oxygenation and support ventilation performed (e.g. oxygen insufflation, ventilation)		☐1	☐1
Circulation			
11. pulse checked		☐1	☐1
12. possible shock signs and hypoperfusion (e.g. skin colour, temperature and moisture, capillary refilling time) looked for		☐1	☐1
13. bleeding control thorax		☐1	☐1
14. bleeding control abdomen		☐1	☐1
15. bleeding control pelvis		☐1	☐1
16. bleeding control thighs		☐1	☐1
17. IV lines		☐1	☐1
18. necessary measures regarding bleeding control performed (e.g. pressure bandage, tourniquet, haemostyptics)		☐1	☐1
19. necessary measures regarding shock therapy performed (e.g. infusion therapy, tranexamic acid)		☐1	☐1
Disability			
20. vigilance checked		☐1	☐1
21. motor/sensoric responses checked		☐1	☐1
22. pupils examined		☐1	☐1
23. treatment appropriate to the D findings		☐1	☐1
Exposure			
24. body temperature maintained - recognised temperature		☐1	☐1
25. further injuries looked for		☐1	☐1

2.0 Secondary assessment	Application	Timely
1. medical history (SAMPLE) checked	☐0.5	☐0.5
2. vital signs measured (blood pressure, ECG, e.g.)	☐0.5	☐0.5
3. continued detailed physical exam performed	☐0.5	☐0.5
4. further necessary diagnostics and measures performed	☐0.5	☐0.5

Performance Assessment of Emergency Teams and Communication in Trauma Care
PERFECT-Checklist

3.0 Procedures	Application
1. Team performed a *structured* (ABCDE) approach	☐2
2. Team did no further harm through unnecessary measures/treatment	☐2
3. The speed of patient care was appropriate to the patient's condition	☐2
4. Team performed rapid identification and management of life-threatening conditions	☐2
5. An appropriate analgesia was performed	☐2

4.0 Skills		Performed	Indication correct?	Performance (duration, positioning technique) 4=excellent 3=good 2=fair. 1=poor
Cervical collar	*Cervical collar was applied in adequate time and manner (cervical collar applied with ≥2 persons).*	☐ yes	☐ yes	☐4 ☐3 ☐2 ☐1
Immobilisation (e.g. spine board)	*Immobilisation was performed in adequate time and manner*	☐ yes	☐ yes	☐4 ☐3 ☐2 ☐1
Tourniquet	*Tourniquet was applied in adequate time and manner*	☐ yes	☐ yes	☐4 ☐3 ☐2 ☐1
Thoracic (needle) decompression	*Thoracic (needle) decompression was performed in adequate time and manner*	☐ yes	☐ yes	☐4 ☐3 ☐2 ☐1
Pelvic binder	*Pelvic binder was applied in adequate time and technique*	☐ yes	☐ yes	☐4 ☐3 ☐2 ☐1
Skills overall	*Overall skills performance*	☐ necessary skills were mostly performed	☐ indication mostly correct	☐4 ☐3 ☐2 ☐1

5.0 Trauma communication	Application
1. potentially critical/non-critical patient stated	☐1
2. (no) A problem stated	☐1
3. (no) B problem stated	☐1
4. (no) C problem stated	☐1
5. (no) D problem stated	☐1
6. critical/non-critical patient stated	☐1
7. 10-for10/team-timeout/team information performed	☐1
8. appropriate trauma centre informed	☐1

6.0 Non-technical skills		Performance 4=excellent 3=good 2=fair. 1=poor
Situation awareness and decision making	*Team gathers information, anticipates and re-evaluates. Team keeps procedures in mind, adapts to various situations, and allocates attention wisely.*	☐4 ☐3 ☐2 ☐1
Leadership and teamwork	*The team leader recognisably leads the team and coordinates the teamwork. Team members follow the leader and complete the task together.*	☐4 ☐3 ☐2 ☐1
Workload management	*Team sets priorities dynamically, coordinates activities and follows standards.*	☐4 ☐3 ☐2 ☐1
Communication	*Team communicates effectively, anticipates and exchanges information. There are clearly stated plans and intentions.*	☐4 ☐3 ☐2 ☐1

7.0 Global rating scale	
1.	☐1 ☐2 ☐3 ☐4 ☐5 ☐6 1=poor 6=excellent

Die PERFECT-Checklist (Häske et al. 2018)

7 Erklärungen zum Eigenanteil

Die Arbeit wurde in der Berufsgenossenschaftlichen Unfallklinik, Klinik für Unfall- und Wiederherstellungschirurgie, an der Universität Tübingen unter Betreuung von Prof. Dr. med. Ulrich Stöckle durchgeführt. Die Arbeitsgruppe setzte sich wie nachfolgend zusammen und wurde fakultativ ergänzt:

David Häske, MSc MBA (Doktorand), Prof. Dr. med. Ulrich Stöckle (Doktorvater), PD Dr. med. Stefan Beckers, MME (Medizindidaktik)[1], Dr. med. Marzellus Hofmann, MME (Medizindidaktik)[2], Prof. Dr. Rolf Lefering (Statistik)[3], Dr. med. Matthias Münzberg (Medizin)[4]

1) Klinik für Anästhesiologie, Uniklinik RWTH Aachen ▪ 2) Fakultät für Gesundheit, Universität Witten/Herdecke ▪ 3) Fakultät für Gesundheit, Institut für Forschung in der Operativen Medizin (IFOM), Universität Witten/Herdecke ▪ 4) Klinik für Unfallchirurgie und Orthopädie, BG-Unfallklinik Ludwigshafen

Practice report: Structured training to improve quality of care in emergency medical service. On-scene supervision: A new approach to emergency medical service training in Wiesbaden and Rheingau-Taunus-Kreis? (Häske et al. 2013)

David Häske hatte das Konzept mitgestaltet, die Daten gesammelt, statistisch ausgewertet und das Manuskript verfasst. PD Dr. med. Christoph G. Wölfl, Dr. med. Christian Frank, Dr. med. Götz Brodermann und Bernhard Gliwitzky waren mit der Problemanalyse beschäftigt und hatten das Fortbildungkonzept mitentwickelt. Dr. Dr. Michael Kreinest hatte die statistische Auswertung unterstützt. Johannes Horter, Arnold J. Suda und PD Dr. med. Stefan K. Beckers, MME hatten ebenfalls an der Konzeption der Fortbildungsreihe mitgewirkt.

The effect of paramedic training on pre-hospital trauma care (EPPTC-study): a study protocol for a prospective semi-qualitative observational trial (Häske et al. 2014)

David Häske entwickelte das Studiendesign, entwarf das Protokoll und verfasste das Manuskript. PD Dr. med. Stefan Beckers, MME und Dr. med. Marzellus Hofmann, MME assistierten bei der Entwicklung des Studiendesigns und Studienprotokolls, lasen das Manuskipt Korrektur und gaben Expertentipps. Dr. med. Matthias Münzberg assistierte bei der Entwicklung des Studiendesigns, las das Mansukript Korrektur und gab Expertentipps.

Comparison of the Prehospital Trauma Life Support recommendations and the German national guideline on treatment of patients with severe and multiple injuries (Häske et al. 2016)

David Häske erstellte das Studienkonzept und den Vergleich der Kernaussagen, entwickelte die Methodik, das Rating-System und verwaltete die Daten. Er analysierte die Daten und schrieb das Manuskript. Dr. med. Münzberg assistierte bei der Erstellung des Studienkonzepts und den Vergleich der Kernaussagen. PD Dr. med. habil. Bernhard, Prof. Dr. med. Heller, Dr. med. Uwe Schweigkofler und Dr. med. Münzberg waren an der Analyse und Auswertung der Daten beteiligt. Dr. Lance Stuke, MD MPH und Bernhard Gliwitzky führten Textanalysen durch.

Subjective Safety and self-confidence in prehospital Trauma Care and Learning Progress by Paramedics after trauma-courses. Part of the prospective mixed-methods longitudinal EPPTC-trial (Häske et al. 2017a)

David Häske hat das Studiendesign entwickelt, die Daten gesammelt und statistisch ausgewertet, das Manuskript verfasst und verantwortet die endgültige Version der Publikation. PD Dr. med. Stefan Beckers, MME und Dr. med. Marzellus Hofmann, MME haben zur Entwicklung des Studiendesigns und des Studienprotokolls beigetragen, das Manuskript Korrektur gelesen und standen mit Expertenrat zur Seite. Prof. Dr. Rolf Lefering hat zur Entwicklung des Studiendesigns beigetragen und die statistische Auswertung geprüft. Bernhard Gliwitzky hat im Bereich Material und Logistik, sowie der Studienkonzeption zur Studie beigetragen, das fertige Manuskript Korrektur gelesen und stand mit Expertenrat zur Seite. Dr. med. Matthias Münzberg hat an der Studienkonzeption und am Studiendesign mitgewirkt, das Manuskript mehrmals Korrektur gelesen und stand mit Expertenrat zur Seite.

Subjective Safety and self-confidence in prehospital Trauma Care and Learning Progress by Paramedics after trauma-courses. Part of the prospective mixed-methods longitudinal EPPTC-trial (Häske et al. 2017b)

David Häske hat das Studiendesign entwickelt, die Fragebögen entwickelt, die Daten gesammelt und statistisch ausgewertet, das Manuskript verfasst und verantwortet die endgültige Version der Publikation. PD Dr. med. Stefan Beckers, MME und Dr. med. Marzellus Hofmann, MME haben zur Entwicklung des Studiendesigns und des Studienprotokolls beigetragen, bei der Daten- und Ergebnisinterpretation assistiert, das Manuskript Korrektur gelesen und standen mit Expertenrat zur Seite. Prof. Dr. Rolf Lefering hat zur Entwicklung des Studiendesigns beigetragen und die

statistische Auswertung überprüft. Dr. med. Matthias Münzberg hat an der Studienkonzeption und am Studiendesign mitgewirkt, das Manuskript mehrmals Korrektur gelesen und stand mit Expertenrat zur Seite. Prof. Dr. Vassilios Papathanassiou hat bei der Erstellung der Fragebogen beraten, bei der Faktorenanalyse und der Interpretation der Analysen zur Seite gestanden.

Performance Assessment of Emergency Teams and Communication in Trauma Care (PERFECT Checklist) – explorative analysis, development and validation of the PERFECT Checklist: part of the prospective longitudinal mixed-methods EPPTC trial

David Häske hat das Studiendesign entwickelt, die Videodaten aufgenommen, die explorative Analyse gemacht und die Daten statistisch ausgewertet, war Teil des Expertpanels und hat das Manuskript verfasst. PD. Dr. med. Stefan Beckers, MME und Dr. med. Marzellus Hofmann, MME haben zur Entwicklung des Studiendesigns und des Studienprotokolls beigetragen, bei der Daten- und Ergebnisinterpretation assistiert, waren Teil des Expertpanels, haben das Manuskript Korrektur gelesen und standen mit Expertenrat zur Seite. Prof. Dr. Rolf Lefering hat zur Entwicklung des Studiendesigns beigetragen und die statistische Auswertung überprüft, hat das Manuskript Korrektur gelesen und standen mit Expertenrat zur Seite. Christine Preiser, M.A. hat bezüglich der qualitativen Analyse beraten, habt das Manuskript Korrektur gelesen und standen mit Expertenrat zur Seite. Dr. med. Matthias Münzberg hat an der Studienkonzeption und am Studiendesign mitgewirkt, war Teil des Expertpanels, hat das Manuskript Korrektur gelesen und stand mit Expertenrat zur Seite.

Ich versichere, dass ich das Manuskript selbständig verfasst zu haben und keine weiteren als die von mir angegebenen Quellen verwendet zu haben.

Tübingen, den

David Häske

8 Veröffentlichungen

Häske D, Beckers SK, Hofmann M, Lefering R, Preiser C, Gliwitzky B, Grützner PA, Stöckle U, Münzberg M (2018) Performance Assessment of Emergency Teams and Communication in Trauma Care (PERFECT checklist)—Explorative analysis, development and validation of the PERFECT checklist. Part of the prospective longitudinal mixed-methods EPPTC trial. PLoS ONE 13(8):e0202795. doi:10.1371/journal.pone.0202795