Acta Anaesthesiol Scand 2008; **52**: 914–919
Printed in Singapore.

ACTA ANAESTHESIOLOGICA SCANDINAVICA
doi: 10.1111/j.1399-6576.2008.01723.x

Standard basic life support vs. continuous chest compressions only in out-of-hospital cardiac arrest

T. M. Olasveengen[1,2], L. Wik[2,3] and P. A. Steen[2,3,4,5]
[1]Department of Anaesthesiology, Ullevål University Hospital, Oslo, Norway, [2]Institute for Experimental Medical Research, Ullevål University Hospital, Oslo, Norway, [3]The National Competence Centre for Emergency Medicine, Ullevål University Hospital, Oslo, Norway, [4]University of Oslo, Faculty Division Ullevål University Hospital, Oslo, Norway and [5]Division of Prehospital Medicine, Ullevål University Hospital, Oslo, Norway

Background: The importance of ventilations after cardiac arrest has been much debated recently and eliminating mouth-to-mouth ventilations for bystanders has been suggested as a means to increase bystander cardiopulmonary resuscitation (CPR). Standard basic life support (S-BLS) is not documented to be superior to continuous chest compressions (CCC).
Methods: Retrospective, observational study of all non-traumatic cardiac arrest patients older than 18 years between May 2003 and December 2006 treated by the community-run emergency medical service (EMS) in Oslo. Outcome for patients receiving S-BLS was compared with patients receiving CCC. All Utstein characteristics were registered for both patient groups as well as for patients not receiving any bystander CPR by reviewing Ambulance run sheets, Utstein forms and hospital records. Method of bystander CPR as well as dispatcher instruction was registered by first-arriving ambulance personnel.
Results: Six-hundred ninety-five out of 809 cardiac arrests in our EMS were included in this study. Two-hundred eighty-one (40%) received S-CPR and 145 (21%) received CCC. There were no differences in outcome between the two patient groups, with 35 (13%) discharged with a favourable outcome for the S-BLS group and 15 (10%) in the CCC group ($P = 0.859$). Similarly, there was no difference in survival subgroup analysis of patients presenting with initial ventricular fibrillation/ventricular tachycardia after witnessed arrest, with 32 (29%) and 10 (28%) patients discharged from hospital in the S-BLS and CCC groups, respectively ($P = 0.972$).
Conclusions: Patients receiving CCC from bystanders did not have a worse outcome than patients receiving standard CPR, even with a tendency towards a higher distribution of known negative predictive features.

Accepted for publication 2 May 2008

Good-quality bystander cardiopulmonary resuscitation (CPR) increases survival after out-of-hospital cardiac arrest.[1–3] The rate of bystander CPR varies considerably (14–53%),[3–8] and increasing the rate of bystander CPR is considered to be important to strengthen the chain of survival. Studies exploring bystander reluctance to give CPR have identified unwillingness to perform mouth-to-mouth ventilations as a major obstacle.[9,10]

The importance of ventilations is being debated considerably in resuscitation science at present, and our increasing knowledge over the past decade has gradually modified current CPR guidelines, with more emphasis on chest compressions and a subsequent decrease in ventilations delivered per minute.[11,12]

In a randomised study of telephone-instructed CPR in Seattle, survival tended to be higher with instructions in chest compressions only vs. standard basic life support (S-BLS), 14.6% vs. 10.4%, $P = 0.18$.[13] In a recent large prospective, observational study in Japan,[14] there was no significant difference in 30-day survival with good neurological outcome, 6% with chest compressions only vs. 4% for standard BLS ($P = 0.146$), but higher survival with chest compressions only for the subgroup with ventricular fibrillation (VF) or ventricular tachycardia (VT) as initial rhythm (19% vs. 11%, $P = 0.041$). An accompanying editorial called for

Institutions where the work was performed: University of Oslo and Ulleval University Hospital, Oslo, Norway.

urgent changes in the current guidelines, advocating continuous chest compressions (CCC) as the preferred method for bystander CPR in patients who suddenly collapse.[15]

Any scientific process developing new treatment guidelines should rely on as many independent studies as possible to support changes in treatment protocols. The aim of this study is therefore to test the reproducibility of earlier published data,[13,14] suggesting that CCC are at least as effective as standard CPR for bystanders.

Material and methods

Description of emergency medical service (EMS)
The city of Oslo has a one-tiered centralised community-run EMS system for a population of 540,000. On weekdays, between 7:30 and 22:00 hours, a physician-manned ambulance staffed by two paramedics and an anaesthesiologist functions on the same level as the regular paramedic-staffed ambulances. The 2005 ERC guidelines were implemented in January 2006. Before this, 2000 ERC guidelines were followed modified with 3 min of CPR before the first defibrillation attempt. Endotracheal intubation was the standard method for securing the airways, with uninterrupted chest compressions and 12 ventilations/min thereafter.

Nurses and paramedics staff the dispatch centre. A maximum of two operators are involved, with a median interval for dispatch call processing of 2.6 min.[16] Telephone CPR instruction with chest compressions only was offered to callers. Because of an ongoing randomised study of the effect of intravenous (i.v.) access and drugs in the Oslo EMS, some of our included patients are also included in this study registered at clinicaltrials.gov (NCT00121524). Less than half of the patients will therefore be expected to have received i.v. drugs during resuscitation.

Study design and recruitment
All patients older than 18 years suffering from non-traumatic out-of-hospital cardiac arrests of all causes from May 2003 through 2006 were studied retrospectively. Upon arrival, ambulance personnel assessed whether bystander CPR was given, and if so, which method was used and whether the bystanders had received dispatcher CPR assistance. Locally adapted Utstein-style forms[17] (with information on type of bystander CPR upon arrival of first ambulance), dispatcher recordings and ambulance and hospital records are routinely collected and reviewed at The National Competence Centre for Emergency Medicine (Ullevål University Hospital, Oslo, Norway).

Statistical analysis
Statistical calculations were performed using a spreadsheet programme (Excel 2002, Microsoft Corp., Redmond, WA) and a statistical software package (SPSS 14.0, SPSS Inc., Chicago, IL). Values are given as means with standard deviations, except for response times given as medians with 95% confidence intervals (CIs). CIs for medians were calculated using normal approximation described by Altman.[18] Differences between the two groups were analysed using Students t-tests for continuous data and χ^2 with continuity correction for categorical data. P-values <0.05 were considered to be significant.

Prognostic factors found to be significant in preliminary univariate and bivariate analyses were included in a multivariate logistic regression analysis together with the BLS method (dependent variable, discharged from hospital alive). The results from the multivariate logistic regression analysis were reported as adjusted odds ratios with 95% CIs and P-values.

Results

Between May 2003 and 2006, there were 809 cardiac arrests treated by our EMS. Ninety-three (11%) were ambulance witnessed, 15 (2%) were only given mouth-to-mouth ventilations by bystanders and for six cases information on bystander CPR was missing. Six-hundred ninty-five patients were subsequently included in our study, with 281 (40%) receiving S-BLS, 145 (21%) receiving CCC and 269 (39%) receiving no BLS. (Fig. 1) The patient group receiving CCC had more arrests occurring at home (58% vs. 41%, $P = 0.002$), less in public places (29% vs. 42%, $P = 0.009$) and were more frequently found in asystole (54% vs. 43%, $P = 0.038$) and less frequently found in VF/VT (33% vs. 46%, $P = 0.018$) compared with the S-BLS group (Table 1).

After ambulance arrival, fewer shocks were delivered (median 0 vs. 1, $P = 0.019$) and i.v. access was established less frequently (51% vs. 66%, $P = 0.004$) in the CCC group compared with the S-BLS group. Adrenaline and amiodarone were administered more often in the S-BLS group (48%

and 13%) compared with the CCC group (37% and 6%) ($P = 0.050$ and $P = 0.041$) (Table 2). There was no difference in randomisation for i.v. access (vs. no i.v. access) before return of spontaneous circulation between the S-BLS and CCC groups (51% vs. 47%, $P = 0.476$).

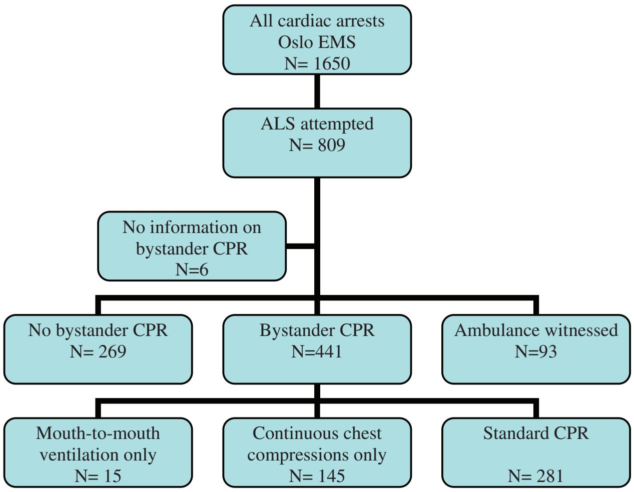

Fig. 1. Flow chart for patients with an out-of-hospital cardiac arrest in the Oslo emergency medical system (EMS) from May 2003 through 2006. ALS, advanced life support; CPR, cardiopulmonary resuscitation.

There were no significant differences in outcome between the two patient groups. Thirty-five (13%) were discharged from the hospital alive in the S-BLS group and 15 (10%) in the CCC group ($P = 0.647$) (Table 3), and for subgroups with witnessed arrests, 34 (18%) and 12 (14%), respectively ($P = 0.586$), or for subgroups with initial VF/VT after witnessed arrest, 32 (29%) and 10 (28%) patients, respectively ($P = 0.972$).

The following prognostic factors were found to be significant in preliminary univariate (and bivariate) analyses: gender ($P = 0.011$), atropine administration ($P = 0.000$), bystander-witnessed arrest ($P = 0.000$), shocked vs. not shocked ($P = 0.000$), arrest occurring at home ($P = 0.007$), arrest occurring in a public place (0.018), initial VF/VT ($P = 0.000$), initial asystole ($P = 0.000$), age ($P = 0.000$), response time ($P = 0.000$) and time from arrest to advanced life support ($P = 0.001$). Only age, response time, gender, bystander witnessed and initial VF/VT rhythm were entered into the regression model as the remaining variables reflect at least one of the above variables.

The logistic analysis revealed that favourable outcomes (an increased likelihood of survival) were associated with a short response interval, young age, initial VF/VT and witnessed arrests.

Table 1

Demographic characteristics.

	No basic life support (BLS)	Continuous chest compressions (CCC)	Standard BLS (S-BLS)	CCC vs. S-BLS (*P*-value)
Episodes included	269	145	281	
Age (years)	65 ± 17	62 ± 18	63 ± 18	0.398
Males (%)	195 (73)	97 (67)	209 (74)	0.130
Cardiac aetiology (%)	177 (67)	104 (72)	214 (76)	0.379
Location of arrest				
Home	180 (67)	84 (58)	116 (41)	0.002
Work	4 (2)	7 (5)	14 (5)	1.000
Public	65 (24)	42 (29)	119 (42)	0.009
Other	20 (7)	12 (8)	32 (11)	0.405
Bystander witnessed	181 (67)	85 (59)	191 (68)	0.050
Dispatch-assisted CPR	–	72 (48)	71 (25)	0.000
Initial rhythm				
VF/VT	70 (26)	48 (33)	128 (46)	0.018
Asystole	152 (57)	78 (54)	120 (43)	0.038
PEA	45 (17)	18 (12)	29 (10)	0.624
Other/unknown	2 (1)	1 (1)	4 (1)	0.848
Response time (min)	8 (5)	9 (5)	9 (6)	0.547
Time from arrest to ALS*	10 (8)	13 (9)	12 (12)	0.103

*Missing information for 56 cases in No BLS group, 21 in CCC group and 51 in S-BLS group.
All variables given as numbers (percentages in parenthesis) except age (mean ± SD) and response time and time from arrest to ALS (minutes, median with interquartile range). Differences between groups were analysed using Students *t*-tests for continuous data and χ^2 for categorical data.
ALS, advanced life support; PEA, pulseless electrical activity; SD, standard deviation; VF/VT, ventricular fibrillation/ventricular tachycardia.

Table 2

Out-of-hospital treatment.

	No basic life support (BLS)	Continuous chest compressions (CCC)	Standard BLS (S-BLS)	CCC vs. S-BLS (*P*-value)
Episodes included	269	145	281	
Defibrillation	92 (34)	62 (43)	142 (51)	0.156
No. of shocks	0 (1)	0 (2)	1 (4)	0.019
No. of shocks when defibrillated	2 (5)	2 (4)	3 (4)	0.075
Intubation	230 (86)	121 (83)	248 (88)	0.180
I.v. drugs during resuscitation	116 (43)	60 (41)	142 (51)	0.077
Adrenaline	110 (41)	54 (37)	134 (48)	0.050
Atropine	70 (26)	32 (22)	67 (24)	0.756
Amiodarone	19 (7)	9 (6)	37 (13)	0.041

All variables given as numbers (percentages in parenthesis) except no. of shocks given as median with interquartile range. Differences between groups were analysed using Students *t*-tests for continuous data and χ^2 for categorical data.
I.v., intravenous.

Table 3

Outcome – admitted to hospital, admitted to intensive care unit (ICU) and discharged from hospital.

	No basic life support (BLS)	Continuous chest compressions (CCC)	Standard BLS (S-BLS)	CCC vs. S-BLS (*P*-value)
Episodes included	269	145	281	
Any ROSC during resuscitation	88 (33)	53 (37)	105 (37)	0.591
Admitted to hospital	91 (34)	57 (39)	112 (43)	0.478
With ROSC	68 (25)	42 (29)	90 (32)	0.591
With ongoing CPR	23 (9)	15 (10)	32 (11)	0.871
Admitted to ICU	65 (24)	46 (32)	91 (32)	1.000
Discharged alive	23 (9)	15 (10)	35 (13)	0.647
CPC 1	20	11	27*	
CPC 2	3	3	4	
CPC 3	1	1	3	

*CPC score not available for one patient in the S-BLS group.
All variables given as numbers (percentages in parenthesis). Differences between groups were analysed using χ^2 tests.
CPC, cerebral performance category; ROSC, return of spontaneous circulation.

The method of BLS (CCC only vs. S-BLS) was not significant in this logistic model (Table 4).

Discussion

Our results support earlier studies suggesting that there are no significant differences in outcome for patients receiving CCC compared with standard BLS from bystanders.[2,13,14,19] There was no significant difference in overall survival in the most recent Japanese study with continuous compressions vs. standard BLS ($P = 0.146$), but *post hoc* subgroup analysis gave higher survival rates with CCC than standard BLS for witnessed out-of-hospital arrests with apnoea, shockable rhythms and short periods of untreated arrests. We found no such subgroup with better outcome without ventilation, but the material is small and the opposite was not the case either.

Table 4

Multivariate logistic regression analysis of prognostic factors for survival.

Prognostic factors	Adjusted odds ratio	95% CI	*P*-value
BLS method (CCC vs. S-BLS)	1.19	0.56, 2.54	0.657
Age (per year)	0.96	0.94, 0.98	0.000
Response time (per min)	0.84	0.75, 0.93	0.001
Gender (male vs. female)	2.42	0.87, 6.72	0.089
Witnessed	4.21	1.33, 13.33	0.015
Initial VF/VT	10.35	3.94, 27.17	0.000

Prognostic factors that were found to be significant in preliminary univariate and bivariate analyses were included in this multivariate logistic regression analysis to detect independent factors potentially affecting survival in the standard basic life support (S-BLS) group vs. continuous chest compression (CCC) group.
CI, confidence interval; VF/VT, ventricular fibrillation/ventricular tachycardia.

This indicates that chest compression only is at least as good as standard BLS for non-traumatic out-of-hospital cardiac arrests in adults. Although this might be the case for the majority of cardiac arrest victims who have a sudden arrest of cardiac origin, we do not believe the data are sufficiently strong to advocate this approach to all cardiac arrest victims. There are groups of patients with asphyxia-related arrests such as children, victims of intoxications or near-drowning who at least theoretically should benefit more from an open airway and active ventilation. In the city of Oslo, there are four times as many patients with drug overdose who require ventilatory assistance only than patients who require full CPR. Mouth-to-mouth ventilation must not be a forgotten art. It is also a major concern that differentiating treatment strategies for lay people may result in a decreased rate of bystander CPR rather than an increase. Instructions to lay people should be kept as simple as possible, with as few changes as possible unless based on very solid data.

An important argument for removing mouth-to-mouth ventilations is the assumption that it will increase the willingness of lay people to perform bystander CPR. This is largely deduced from questionnaire-based studies asking people to guess how they might react in a hypothetical situation.[20,21] It remains to be proven that removing mouth-to-mouth ventilations will increase bystander CPR. With the large differences in reported bystander involvement, it seems that other strategies might be effective in improving the frequency of bystander CPR. In Norway, the frequency has been high for decades, usually reported in the 40–60% range.

Detrimental effects of compression pauses constitute most of the rationale for increased emphasis on chest compressions in the 2005 CPR guidelines.[11,12] Earlier studies[2,13,14,19] as well as most of our own data were collected while the old guidelines were in effect. We question whether the guidelines should be changed again until we have more information with the current 30 : 2 compression-to-ventilation ratio and from areas with better overall survival than the Japanese study[14] and longer response intervals than typically reported from King County, Washington.[13]

Hallstrom et al. documented that dispatchers spent 2.4 min instructing bystanders to give standard BLS, and that bystanders receiving such instructions were more likely to not complete their instructions compared with bystanders instructed to give chest compressions only. Arrival of EMS personnel before completion of dispatch instructions and declaring the CPR instructions too difficult were more than twice as common in the standard BLS group.[13] These are compelling arguments suggesting dispatchers limit their instructions to chest compressions for untrained bystanders.

In the present study, the S-BLS group had significantly more patients with witnessed arrests occurring in public places, with VF or VT as initial rhythm. Fewer bystanders in this group also received telephone assistance when performing CPR. This could be expected as it is likely that a larger proportion of bystanders with prior CPR training would start S-BLS without any dispatch assistance. Despite this uneven distribution of known positive predictors, outcome remained the same for the two BLS groups after factoring in these variables in a multivariate logistic regression model. Interestingly, the S-BLS group received more i.v. drugs than the CCC group, even though there was no difference in i.v. randomisation. There was also a tendency towards administering more shocks to the shocked patients in the S-BLS group. This raises the question of whether it is the S-BLS treatment itself that leads to increased need for drug and shock treatment or whether this is due to some confounding factor. One such confounder may be the higher incidence of cardiac arrest occurring in public places. Cardiac arrests in public places are known to a have better prognosis, and a higher level of ambition by ambulance personnel would be expected. An increased expectation by bystanders for ambulance personnel to exhaust all options might also be more common in a public setting.

Although no differences could be detected in outcome for the S-BLS and CCC groups, even after applying a multivariate regression model, this was not a randomised trial and the results must be interpreted with caution. A variety of other, unknown confounders may influence our results, and prospective, randomised clinical trials are needed.

Conclusions

Patients receiving CCC from bystanders had no worse outcome than patients receiving standard CPR, even with a tendency towards a worse distribution of several known negative predictive features.

Acknowledgements

We thank all the physicians and paramedics working in the Oslo EMS as well as the personnel at the dispatch unit for their

efforts in guiding callers for performing CPR. We also thank Stale Nygard and Kjetil Sunde for help with the statistics. The study was supported by grants from Eastern Norway Regional Health Authority, Ullevål University Hospital, Norwegian Air Ambulance Foundation, Laerdal Foundation for Acute Medicine and Anders Jahres Fund.
Conflict of interest: Olasveengen has no conflicts of interest to declare. Wik is on a Medical Advisory Board for Physio-control, has in the past consulted for Laerdal and Jolife and is the principal investigator for a multicentre mechanical chest compression device study sponsored by Zoll. Steen is a member of the board of directors for Laerdal Medical and The Norwegian Air Ambulance.
Financial support: The study was supported by grants from Eastern Norway Regional Health Authority, Ullevål University Hospital, Norwegian Air Ambulance Foundation, Laerdal Foundation for Acute Medicine and Anders Jahres Fund.
Author contributions: Olasveengen has full access to all generated data and takes full responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: Olasveengen and Steen.
Acquisition of data: Olasveengen and Wik.
Drafting of the manuscript: Olasveengen and Steen.
Critical revision of the manuscript for important intellectual content: Olasveengen, Wik and Steen.
Statistical expertise: Olasveengen and Steen.
Obtained funding: Steen.
Administrative, technical or material support: Steen and Wik.
Study supervision: Steen.

References

1. Gallagher EJ, Lombardi G, Gennis P. Effectiveness of bystander cardiopulmonary resuscitation and survival following out-of-hospital cardiac arrest. *JAMA* 1995; **274**: 1922–5.
2. Van Hoeyweghen RJ, Bossaert LL, Mullie A, Calle P, Martens P, Buylaert WA, Delooz H. Quality and efficiency of bystander CPR. Belgian Cerebral Resuscitation Study Group. *Resuscitation* 1993; **26**: 47–52.
3. Wik L, Steen PA, Bircher NG. Quality of bystander cardiopulmonary resuscitation influences outcome after prehospital cardiac arrest. *Resuscitation* 1994; **28**: 195–203.
4. Stiell IG, Wells GA, Field B, Spaite DW, Nesbitt LP, De Maio VJ, Nichol G, Cousineau D, Blackburn J, Munkley D, Luinstra-Toohey L, Campeau T, Dagnone E, Lyver M. Advanced cardiac life support in out-of-hospital cardiac arrest. *N Engl J Med* 2004; **351**: 647–56.
5. Sunde K, Pytte M, Jacobsen D, Mangschau A, Jensen LP, Smedsrud C, Draegni T, Steen PA. Implementation of a standardised treatment protocol for post resuscitation care after out-of-hospital cardiac arrest. *Resuscitation* 2007; **73**: 29–39.
6. Wenzel V, Krismer AC, Arntz HR, Sitter H, Stadlbauer KH, Lindner KH. A Comparison of vasopressin and epinephrine for out-of-hospital cardiopulmonary resuscitation. *N Engl J Med* 2004; **350**: 105–13.
7. Herlitz J, Bang A, Gunnarsson J, Engdahl J, Karlson BW, Lindqvist J, Waagstein L. Factors associated with survival to hospital discharge among patients hospitalised alive after out of hospital cardiac arrest: change in outcome over 20 years in the community of Goteborg, Sweden. *Heart* 2003; **89**: 25–30.
8. Fairbanks RJ, Shah MN, Lerner EB, Ilangovan K, Pennington EC, Schneider SM. Epidemiology and outcomes of out-of-hospital cardiac arrest in Rochester, New York. *Resuscitation* 2007; **72**: 415–24.
9. Locke CJ, Berg RA, Sanders AB, Davis MF, Milander MM, Kern KB, Ewy GA. Bystander cardiopulmonary resuscitation. Concerns about mouth-to-mouth contact. *Arch Intern Med* 1995; **155**: 938–43.
10. Brenner BE, Kauffman J. Reluctance of internists and medical nurses to perform mouth-to-mouth resuscitation. *Arch Intern Med* 1993; **153**: 1763–9.
11. 2005 American Heart Association Guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation* 2005; **112** (Suppl. 1: IV): 1–203.
12. 2005 International consensus on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations. *Resuscitation* 2005; **67** (Suppl. 1): S3–186.
13. Hallstrom A, Cobb L, Johnson E, Copass M. Cardiopulmonary resuscitation by chest compression alone or with mouth-to-mouth ventilation. *N Engl J Med* 2000; **342**: 1546–53.
14. Cardiopulmonary resuscitation by bystanders with chest compression only (SOS-KANTO): an observational study. *Lancet* 2007; **369**: 920–6.
15. Ewy GA. Cardiac arrest – guideline changes urgently needed. *Lancet* 2007; **369**: 882–4.
16. Naess AC, Steen PA. Long term survival and costs per life year gained after out-of-hospital cardiac arrest. *Resuscitation* 2004; **60**: 57–64.
17. Jacobs I, Nadkarni V, Bahr J, Berg RA, Billi JE, Bossaert L, Cassan P, Coovadia A, D'Este K, Finn J, Halperin H, Handley A, Herlitz J, Hickey R, Idris A, Kloeck W, Larkin GL, Mancini ME, Mason P, Mears G, Monsieurs K, Montgomery W, Morley P, Nichol G, Nolan J, Okada K, Perlman J, Shuster M, Steen PA, Sterz F, Tibballs J, Timerman S, Truitt T, Zideman DInternational Liason Committee on Resuscitation. Cardiac arrest and cardiopulmonary resuscitation outcome reports: update and simplification of the Utstein templates for resuscitation registries. A statement for healthcare professionals from a task force of the international liaison committee on resuscitation. *Resuscitation* 2004; **3**: 233–49.
18. Altman DG. *Practical statistics for medical research*. London: Chapman & Hall/CRC, 1991.
19. Waalewijn RA, Tijssen JG, Koster RW. Bystander initiated actions in out-of-hospital cardiopulmonary resuscitation: results from the Amsterdam Resuscitation Study (ARRESUST). *Resuscitation* 2001; **50**: 273–9.
20. Ornato JP, Hallagan LF, McMahan SB, Peeples EH, Rostafinski AG. Attitudes of BCLS instructors about mouth-to-mouth resuscitation during the AIDS epidemic. *Ann Emerg Med* 1990; **19**: 151–6.
21. Hew P, Brenner B, Kaufman J. Reluctance of paramedics and emergency medical technicians to perform mouth-to-mouth resuscitation. *J Emerg Med* 1997; **15**: 279–84.

Address:
Theresa M. Olasveengen
Department of Anaesthesiology
Division Ullevål University Hospital
Institute for Experimental Medical Research
Ullevål University Hospital
University of Oslo
N-0407, Oslo
Norway
e-mail: t.m.olasveengen@medisin.uio.no