SLEEP QUALITY DURING AND AFTER CARDIOTHORACIC INTENSIVE CARE AND PSYCHOLOGICAL HEALTH DURING RECOVERY

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Abstract

Background: Intensive care patients experience poor sleep quality. Psychological distress and diminished health-related quality of life are also common among former ICU patients. Coronary artery bypass graft (CABG) surgery is a frequent reason for adults requiring treatment in ICU. The effect of on-pump vs off-pump surgery on sleep and recovery has not been reported.

Objective: To assess sleep quality of CABG patients during and after ICU, psychological wellbeing, HRQOL during recovery and whether on-pump vs off-pump surgery affects sleep and recovery.

Methods: Data were collected in ICU, on the hospital ward, and two months and six months after hospital discharge using validated self-report questionnaires.

Results: The sample (n=101) was mean age 66.6±11.1 years, 79% male and had a median ICU stay of 2 (2-4) days, mean BMI 27.3±4.3 and 75% underwent on-pump surgery. Poor sleep was reported by 62% of patients at six months and by 12% of patients at all time points. Off-pump CABG patients had fewer PTSD symptoms (p=0.02) and better physical HRQOL (p=0.01). In multivariate analysis, prehospital insomnia (p=0.004), and physical (p<0.0005) and mental (p<0.0005) HRQOL were independently associated with sleep quality at six months. There was no association between on-pump vs off-pump CABG and sleep quality at six months.

Conclusions: Sleep quality of postoperative CABG patients was poor in ICU, the hospital ward and up to six months after discharge from hospital. Poor sleep quality at six months was associated with prehospital insomnia, and physical and mental HRQOL at six months, but not with on-pump vs off-pump surgery.

Key words: sleep, psychological, quality of life, coronary artery bypass and thoracic

Introduction

Patients in the intensive care unit (ICU) experience abnormal sleep, with little or no slow wave sleep or rapid eye movement sleep [1-3]. The duration of sleep in 24 hours may be normal but is highly fragmented with nearly 50% of total sleep time occurring during the daytime [2, 4]. Even though the exact function of human sleep is unknown, it is universally understood to be vital for health and wellbeing; adequate and good quality sleep is considered imperative to brain and bodily restoration [5]. After discharge from hospital, some patients continue to experience poor sleep quality and report compromised psychological health and diminished health related quality of life (HRQOL) [6-12]. The link between sleep problems in ICU and subsequent psychological recovery is still unclear despite the prevalence of these problems among former ICU patients [13].

Coronary artery bypass graft (CABG) surgery is the principal reason for admission for the 147,000 adult patients treated in ICU in Australia and New Zealand annually [14]. Many cardiac surgical patients experience disrupted sleep during their ICU stay and afterwards, with the potential for associated problems during recovery such as delirium [15-19]. There is evidence to suggest that patients who have off-pump CABG have better objective sleep continuity and self-reported sleep quality than on-pump patients, but not less disturbance of mood such as anxiety and depression [20]. This may in part be related to maintenance of better cerebral perfusion during off-pump surgery compared to on-pump surgery [15]. Health related quality of life during recovery appeared to be better for patients undergoing on-pump CABG in one study [21] but had no clinically significant effect in other studies [22, 23].

The majority of ICU sleep data have been collected in settings other than cardiothoracic ICU, which affects the application of findings to CABG patients. Studies performed in the cardiac surgery population have focused largely on mortality and other physical outcomes. There is a paucity of research on the comparison of sleep quality, psychological recovery and HRQOL between patients undergoing on-pump and off-pump CABG surgery. Cardiothoracic ICU patients may experience a unique array of pathophysiological, neurocognitive and

psychological factors, compared to patients with other reasons for treatment in ICU as a result of reduced cerebral perfusion [15] or endothelial damage [24] during surgery. Therefore, the purpose of the current study was to determine the association between sleep quality for patients treated in the cardiothoracic ICU and during recovery, and their psychological health during recovery. Given the potential difference in vascular and therefore neurophysiological effects of surgical technique we sought to compare these outcomes for those who had on-pump and off-pump surgery.

The specific aims were to: i) assess self-reported patients' sleep quality in the ICU, on the hospital ward and at home two and six months after hospital discharge; ii) determine whether patients who experience sleep disruption in the ICU, continue to experience poor sleep quality while recovering after ICU discharge; iii) determine the relationship between patients' sleep disruption and their psychological wellbeing during recovery; iv) determine the differences in sleep quality and psychological wellbeing between patients who undergo 'on-pump' and 'off-pump' CABG.

Methods

This was a prospective observational study with the outcomes of sleep quality and psychological health assessed during recovery while the patient was in the ICU, the hospital ward, and at two and six months after hospital discharge.

Participants

A convenience sample of patients who had undergone CABG was recruited from a metropolitan tertiary referral hospital in Sydney, Australia. The patient inclusion criteria were i) age >17 years; ii) ICU/High dependency unit (HDU) length of stay ≥ two nights; iii) ability to give informed consent; iv) ability to complete study questionnaires in English; v) adequate vision and hearing; vi) medically cleared for discharge from ICU; and vii) no cognitive impairment. Data were collected on 101 patients in total, 65 CABG patients in a similar study (that also included neurosurgical and general ICU patients not in this study), plus an

additional 36 CABG patients in the same cardiothoracic ICU (Figure 1). The records of the first group of patients were reviewed to determine whether they had on- or off-pump surgery. All patients at the study site were assessed for eligibility and cognitive capacity. Written informed consent was obtained using the consent form approved by the Human Research Ethics Committees of the Hospital and the University (HREC project number: 1002-045M).

Data Collection

Demographic and clinical characteristic data were collected from the ICU observation chart and the patients' file. Participants were approached when they were assessed to have sufficient cognitive capacity to provide informed consent. In ICU and the hospital ward, patients chose to complete questionnaires independently or the questions were read to them and their answers documented. After hospital discharge data were collected by mail or telephone interview. A cover letter, questionnaires and a self-addressed prepaid postage envelope were mailed to each patient's address two weeks prior to the two and six month follow-up dates. A telephone call to each patient was made two weeks after the questionnaires were mailed using a standardized telephone transcript to ask if any clarification was needed.

Study instruments

Eight instruments were used in the current study: The Insomnia Severity Index (ISI) [25], Richards-Campbell Sleep Questionnaire (RCSQ) [26], Sleep in the Intensive Care Unit Questionnaire (SICQ) [27] (only item 1, a single visual analogue scale was used to assess sleep; we did not assess factors contributing to self report of sleep quality), Pittsburgh Sleep Quality Index (PSQI) [28, 29], Intensive Care Experience Questionnaire (ICEQ) [30], Depression Anxiety Stress Scales instrument (DASS-21) [31], Post-traumatic Stress Disorder Checklist for Specific Event (PCL-S) [32], and Medical Outcomes Trust Short Form-36 (SF-36) [33]. The instruments are briefly described and the times at which they were administered are provided in Table 1. All instruments have been validated for use at the time

points they were administered in this study. The operational definition of sleep quality encompassed self-perceived satisfaction with a number of different parameters of sleep using different instruments therefore cut-off points for sleep quality were used to classify patients for who reported poor quality sleep and those who reported good quality sleep (according to the recommendations for use and conditions under which they were validated). A data collection sheet was used for severity of illness, pain intensity, anxiety level, age, gender and length of stay.

Data Analysis

Frequencies and percentages were reported for categorical variables. If continuous data were normally distributed, the mean and standard deviation were calculated, or median and interquartile ranges where data were skewed, such as the length of ICU stay.

Univariate analyses were performed to characterize the patients and explore differences between patient groups; for example, 'off-pump' and 'on-pump' surgery. Chi-Square was used to compare categorical data. Normally distributed continuous data were compared using parametric statistics, such as the independent-sample t-test. Non-normally distributed continuous data were compared using a non-parametric statistical test, such as the Mann-Whitney U. After first checking that the assumptions for linear regression were met, multivariate analysis was performed to explore factors independently related to sleep quality on PSQI at six months using multiple regression (using simultaneous loading procedure). Independent variables were determined by selecting normally distributed continuous variables that were related ($p<0.05$) to sleep quality at six months from bivariate analysis (prehospital symptoms of insomnia, physical and mental HRQOL at six months), or had theoretical reason for being included (on- and off-pump surgical techniques). On-pump and off-pump surgical technique was included in the regression as it has been proposed that it makes a difference to recovery [20, 21, 34]. A PSQI cut-off score of 5 was used to define poor sleep [28].

Results

Three-quarters of the participants were male with an average age 67 years. A quarter had off-pump surgery (Table 2). Almost all patients were alert, calm and cooperative on enrolment. Pain intensity scores were low on enrolment and median ICU length of stay was 2.00 days.

The average ISI score was low, but almost 20% of patients had a score indicative of clinical insomnia (Table 3 and 4). The sleep quality in ICU reported on the SICQ was lower than quality of sleep at home. Likewise the RCSQ sleep quality while patients were in the ICU appeared to be lower than when they were in the hospital ward and the PSQI mean score at two months was higher than the PSQI mean score at six months. Three-quarters of patients in the ICU and 72% in the hospital ward reported poor sleep (RCSQ<70mm); over half reported poor sleep in both the ICU and hospital ward (Table 4). Seven percent (n=7) of patients reported having poor sleep quality at all five time points. Twelve patients reported poor sleep quality in the ICU and afterward.

Factors related to patient's sleep quality at six months were compared for patients who reported poor sleep and those who reported good sleep (Table 5). More men than women reported good quality sleep at six months (p=0.02). Almost 89% of female patients reported poor quality sleep at six months (p=0.02). The ISI total score on enrolment was higher for patients with poor sleep quality at six months (p=0.02). The ICEQ awareness of surroundings domain score was higher in patients who reported good sleep quality at six months (p=0.03). Depression, anxiety, stress, total PCL-S and total PSQI scores at two months were higher in patients who reported poor sleep quality at six months (p<0.01). The PCS and MCS scores for the SF-36 were higher in the patients with good sleep quality (p<0.0005). Patients who had on-pump surgery reported higher PCL-S (p=0.02) and DASS depression scores (p=0.04). Patients who had off-pump surgery (Table 7) reported better PCS on the SF-36 (p=0.01).

The specified linear regression model (Table 6), included the independent variables on- or off-CPB pump surgery, prehospital insomnia, physical and mental HRQOL at six months, was statistically significant ($p<0.01$) and explained 55% of the variance in the PSQI scores at six months ($R^2=0.547$). Poorer sleep quality at six months was independently associated with greater prehospital symptoms of insomnia and lower physical and mental HRQOL at six months, but not with on-pump or off-pump surgical technique.

In descriptive analyses it was found that at two months the mean ICEQ domain scores were 35.00 (awareness of surroundings), 12.20 (frightening experiences), 17.00 (recall of experiences) and 14.70 (satisfaction with care). The six month median depression, anxiety and stress scores were 6, 4 and 6, respectively. The mean score for PCL-S was 26.10±9.40. Quality of life on the SF-36 Physical Component Summary (PCS) was 48.90±9.40 and Mental Component Summary (MCS) score was 44.03±10.50. There were no statistically significant differences in ICEQ, PCL-S, DAS-21 and SF-36 scores during recovery between patients who reported poor and good quality sleep while in the cardiothoracic ICU. The proportion of on-pump patients who reported poor quality sleep in the ICU was not significantly different from the proportion of off-pump patients who reported poor quality sleep in the ICU.

Discussion

This study of the sleep quality of CABG patients showed that sleep quality in the ICU, on the hospital ward and at home two and six months after hospital discharge was poor. A proportion had poor sleep at all time points. Sleep quality at six months was independently related to prehospital insomnia, physical and mental HRQOL, but not to specific psychological factors or on-pump vs off-pump bypass.

The results of the current study generally reflect the findings of other previously published studies although the mean RCSQ score was lower than in other studies using the RCSQ [2, 9, 35]. Although the mean values on SICQ and RCSQ in this study were slightly different

from other studies, the overall the quality of cardiothoracic ICU patients' sleep while in ICU was poor and reflective of the findings of international reports [19, 35, 36]. The slightly lower RCSQ score in this study, in contrast to some others, may in part be explained by changes in sedation regimens over recent years. Lighter levels of sedation are used more frequently together with non-pharmacological interventions to reduce anxiety and agitation [37, 38]. Sedation regimens are focused on maintaining individual target sedation levels agreed by the clinical team. These changes in practice may have contributed to greater awareness [37] and thereby the patients' perceptions of lower sleep quality.

Clinical insomnia prior to hospitalization was reported by a fifth of patients. This is consistent with community insomnia prevalence rates, which range from 10 to 20% [39]. Prehospital ISI scores were different between patients with poor and good sleep at six months after hospital discharge and there was an independent association between prehospital ISI score and sleep quality at six months. The predictability of sleep before hospital admission relative to sleep quality at home at six months suggests that the evaluation of pre-hospital sleep quality may assist in identifying patients who are at risk of poor sleep during recovery.

The mean scores for the ICEQ subscales were similar to those published previously [9]. However, in comparison to reports from Rattray [30, 40], the levels were better for awareness of surroundings, frightening experiences and recall of experience, and similar for satisfaction with care. Likely explanations for this are the timing of questionnaire completion and differences in practice, such as sedation and ventilation regimens and severity of illness/diagnosis. Moreover, the patients in the current study may have been better informed and prepared, (i.e. provision of verbal and written preoperative preparation) resulting in better perception of experiences. Poor sleep quality at six months after hospital was correlated with a lower mean score for awareness of surroundings and higher score for frightening experiences. Preparing patients prior to surgery and reassuring them may help to increase awareness, reduce frightening ICU experiences and result in better sleep quality after hospital discharge.

At six months, depression, anxiety and stress scores were similar to those in a non-clinical sample [31] but lower than those in former combined general, cardiothoracic and neurological ICU patients [9]. Previous studies have shown that psychological distress and PTSD are commonly reported by former ICU patients [40-42]. It is estimated that between 30% and 40% of CABG patients are affected by depression, which is higher than the community prevalence [43]. There was a similarity in depression, anxiety and stress scores between this cohort and population norms, which may be a reflection of the improvement in mood associated with increased physical function after revascularization [44]. The short length of ICU and hospital stay, and associated physical improvement and greater patient independence may have increased satisfaction. Our bivariate analysis revealed an association between poor sleep quality at six months and greater depression, anxiety, stress and PTSD symptoms at six months, possibly indicating improved psychological health as a result of better sleep quality or vice versa. Multicollinearity between these factors precluded their inclusion in multivariate analysis.

Health related quality of life was similar to previous studies in former ICU patients [9, 45]. An independent association between both physical and mental HRQOL and poor sleep at six months after discharge was found, concurring with previous study findings [9, 46]. Greater sleep complaints prior to CABG surgery have been found to be associated with greater physical symptoms, poorer physical HRQOL and greater pain sensation after surgery [47]. These findings concur with ours, that prehospital sleep quality may be associated with sleep quality during and after hospitalization and related to the psychological health and HRQOL in CABG patients during recovery.

There was no difference in self-reported ICU sleep quality between patients having on-pump and off-pump CABG surgery, which contrast with the findings of a previous study [20]. Our linear multiple regression model which included on-pump or off-pump surgery, prehospital symptoms of insomnia, and physical and mental HRQOL at six months, explained 55% of the variance in sleep quality six months after discharge. The small proportion of patients

(25%) who had off-pump surgery in a relatively small sample may have resulted in statistical error. The results might be more generalizable if the groups were equal and larger. Another possible explanation is that the physical effects from both surgical techniques may have equalized by the time the patients were followed up.

The limitations to this study include the potential for reporting bias from self-report questionnaires, a relatively small sample size and that it was single-centered. Some patients chose not to complete the study out to six months, as they were free to do. This may also have influenced the final results. Recruiting from a single site may result in patients with specific characteristics which are not generalizable. In addition, sleep quality was measured once at each time point which could be influenced by temporary intrinsic factors (such as urinary retention) and extrinsic (such as sharing a room with a confused patient).

Future research should focus on further investigation of factors affecting the group of patients who have poor sleep in ICU and continue to have poor sleep during recovery. Furthermore, prehospitalization sleep assessment should be included in future ICU investigations into the assessment and improvement of patients' sleep. Finally, exploration is needed into the strategies to improve patients' sleep and psychological health which could potentially improve their HRQOL.

Conclusion

This study demonstrates that patients' self-reported sleep quality after CABG surgery is similarly poor to that of other ICU patients while they are treated in intensive care, on the hospital ward and during recovery. Poor sleep six months after hospital discharge was independently associated with reduced quality of life but not with whether patients had on- or off-pump surgery. A substantial proportion of patients experienced poor sleep quality at all time points, while a small proportion of patients experienced sleep disruption in the ICU and afterward. There remains considerable potential for the testing of clinical practice

interventions to improve the quality of sleep and associated recovery of cardiothoracic intensive care patients.

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What's New?

- The quality of sleep reported by patients who have CABG surgery is similarly poor to that of other ICU patients while they are treated in intensive care, on the hospital ward and during recovery.
- Sleep quality six months after discharge was independently associated with prehospital insomnia symptoms and physical and mental HRQOL at six months, but not with on-pump versus off-pump surgery or other patient characteristics or psychological symptoms during recovery.
- Prehospitalization sleep assessment should be included in future ICU investigations focused on the assessment and improvement of patients' sleep.

Tables and figures

Table 1. Instruments and timelines

Instrument	Reliability (Cronbach's alpha)	Construct and measurement scale **Details of scoring relevant for the current study**	Time administered
Numerical Pain Scale	Not performed	Intensity of pain (0 -10, where 10 was the worst pain possible)	ICU/HDU on Enrolment (day 1 of the study, in person)
Faces Anxiety Scale	Not performed	Level of anxiety (faces displaying features of anxiety rated 1 to 5, where 5 is highest anxiety level)	
Richards-Campbell Sleep Questionnaire (RCSQ)	0.91	Sleep quality (mean score of 5 visual analogue scales, 0 to 100mm, where 0 is the worst sleep quality). Cut off point for poor sleep: <70 mm	
Insomnia Severity Index (ISI)	0.89	Sleep quality and insomnia severity (0 to 28, score 15 suggestive of moderate severity clinical insomnia). Cut off point for moderate insomnia: ≥15 [48]	
Sleep in the Intensive Care Unit Questionnaire (SICQ)-item 1 **only**	Not performed	Sleep quality prior to hospitalization (0 to 10 scale, where 0 is the worst sleep possible)	
Richards-Campbell Sleep Questionnaire (RCSQ)	0.89	Sleep quality	Hospital ward (1 to 2 nights after transfer from ICU, in person)
Sleep in the Intensive Care Unit	Not performed	Sleep quality and sleep disturbances in ICU	

Questionnaire (SICQ)		(measures patients perceptions of sleep quality, mixture of open ended and Likert scale rated items)	
Pittsburgh Sleep Quality Index (PSQI)	0.81	Sleep quality and sleep disturbances at home during the previous month (19 items; score 0 to 21, higher scores indicate poor sleep quality with scores ≥5 indicative of very poor sleep). Cut off point for poor sleep: ≥5 [28]	Six months after hospital discharge (either self-administered or telephone conversation and completed by the researcher)
Depression Anxiety Stress Scales (DASS-21)	Depression 0.91 Anxiety 0.73 Stress 0.91 DASS 0.90	Symptoms of depression, anxiety and stress (21 items; high scores indicate psychological distress)	
Post-traumatic Stress Disorder (PTSD) Checklist for Specific Event (PCL-S)	Re-experiencing 0.87 Avoidance 0.84 Hyperarousal 0.78 PCL-S 0.91	PTSD symptoms	
Medical Outcomes Trust Short Form-36 (SF-36) health survey–Version 2	Physical functioning 0.94 Role physical 0.95 Body pain 0.91 General health 0.85 Vitality 0.85 Social function 0.87 Role-emotion 0.91 Mental health 0.84 Physical component score 0.84 Mental component score 0.85	Physical and mental components of health related quality of life (36 items)	

Table 2. Selected demographic and clinical characteristics of patients on enrolment (n=101)

		N	%
Gender			
Male		79	78.20
Female		22	21.80
Cardiopulmonary bypass pump[a]			
On-pump		75	75.00
Off-pump		25	25.00
Sedation score on enrolment (RASS)[b]			
-1		1	1.00
0		99	98.00
1		1	1.00
	N	**Mean**	**SD[c]**
Age (years)	101	66.60	11.07
BMI (kg/M²)[d]	101	27.30	4.32
Anxiety level on enrolment (1-5)	101	2.28	1.11
	N	**Median**	**IQR (25-75%)[e]**
Pain severity on enrolment (0-10)	101	2.00	0.00-4.00
Length of mechanical ventilation (days)	101	1.00	0.50-1.00
ICU length of stay (days)	101	2.00	2.00-4.00
Hospital length of stay (days)	101	12.00	8.50-15.00

[a] Missing one patient (discontinued), [b] Richmond Agitation Sedation Scale, [c] SD=standard deviation, [d] BMI=body mass index, [e] Interquartile range

Table3. Subjective sleep outcome scores

	N	Mean	SD	Min-Max
Total ISI (0-28)[a]	101	7.85	7.66	0-28
Quality of sleep at home (SICQ) (1-10)[b]				
Reported in ICU[c]	101	6.81	2.52	1-10
Reported in ward	96	6.95	2.39	1-10
Overall quality of sleep in ICU (SICQ) (1-10)[b]	96	4.41	2.40	1-10
Mean total RCSQ (0-100)[c]				
In ICU	100	42.76	29.10	0-100
In ward	96	51.84	25.23	0-100
Total PSQI after hospital discharge(0-21)[a]				
Two months	76	8.18	4.23	1-20
Six months	71	7.92	4.64	1-21

[a] Lower scores are better, [b] Higher scores are better, [c] A cut point of 70/100 on the RSCQ was used to categorise good and poor sleep, based on an average score of prehospital sleep quality of 7/10 on the SICQ

Table 4. Subjective sleep over time

	N	%
Insomnia Severity Index (ISI≥15)		
Clinical insomnia-moderate or severe	20	19.80
Richards-Campbell Sleep Questionnaire (RCSQ) in ICU(RCSQ <70)[a]		
Poor	76	76.00
RCSQ in ward		
Poor (RCSQ<70)	69	71.90
RCSQ in ICU and ward		
Poor in ICU and ward	53	52.50
Poor in ICU or ward	34	35.40
Pittsburgh Sleep Quality Index (PSQI) at two months		
Poor (PSQI>5)	52	68.40
PSQI at 6 months		
Poor (PSQI>5)	44	62.00
PSQI at two and six months		
Poor at two and six months	39	50.00
Poor at two or six months	21	26.90
Sleep quality over time		
Poor-home, ICU, ward, two months and six months after hospital discharge	7	6.90
Poor-ICU, ward, two months and six months after hospital discharge	12	11.90
Poor after hospital discharge only	12	11.90

[a]A cut point of 70/100 on the RCSQ used to categorise good and poor sleep, based on an average score of prehospital sleep quality of 7/10 on the SICQ.

Table 5. Factors related to patient's sleep quality at six months (bivariate comparisons)

		PSQI total>5-poor sleep quality	**PSQI total≤5-good sleep quality**	**N**	***P***
Gender (%)	Female	16 (88.90)	2 (11.10)	18	0.02 [a]
	Male	28 (52.80)	25 (47.20)	53	
Age in years	Mean±SD[b]	65.95±9.97	66.44±10.81	71	0.85[c]
BMI[d] in kg/M²	Mean±SD	27.81±4.89	27.68±3.57	71	0.91[c]
CPB[e] pump (%)	On-pump	34(63.00)	20(37.00)	54	0.98[a]
	Off-pump	10(58.80)	7(41.20)	17	
ISI[f] total score	Median (IQR)[g]	6.00 (2.25-14.75)	2.00 (0.00-9.00)	71	0.02[h]
SICQ[i] Q1 in ICU home sleep	Median (IQR)	7.00 (5.00-8.00)	8.00 (6.00-10.00)	71	0.11[h]
SICQ Q2 ICU sleep quality	Median (IQR)	4.00 (2.00-6.00)	5.00 (2.00-7.00)	68	0.67[h]
RCSQ[j] in ICU total, mm	Median (IQR)	39.30 (20.90-39.30)	36.80 (15.00-74.20)	71	0.89[h]
RCSQ in ward total, mm	Mean±SD	53.84±25.03	55.28±22.91	68	0.82[c]
ICEQ[k] Awareness of surroundings	Median (IQR)	37.00 (33.00-39.00)	40.00 (36.00-42.00)	68	0.03[h]
ICEQ Frightening experiences	Mean±SD	12.39±4.53	11.52±3.82	68	0.03[h]
ICEQ Recall of experiences	Mean±SD	16.93±4.20	18.11±4.35	68	0.27**[c]**
ICEQ Satisfaction with care	Mean±SD	14.78±3.72	14.93±3.39	68	0.87**[c]**
DASS-21-[l]Depression	Median (IQR)	10.00 (2.00-18.00)	2.00 (0.00-8.00)	71	<0.0005[h]
DASS-21-Anxiety	Median (IQR)	7.00 (4.00-12.00)	2.00 (0.00-2.00)	71	<0.0005[h]
DASS-21-Stress	Median (IQR)	10.00 (4.00-18.00)	2.00 (0.00-6.00)	71	<0.0005[h]

		PSQI total>5-poor sleep quality	PSQI total≤5-good sleep quality	N	*P*
PCL-S[m] total	Median (IQR)	26.50 (21.00-35.75)	21.00 (17.00-24.00)	71	<0.0005[h]
Total PSQI[n]-two months	Median (IQR)	10.00 (7.00-12.00)	4.00 (3.00-6.00)	68	<0.0005[h]
SF-36[o] PCS[p]	Mean±SD	40.40±9.03	49.94±10.09	71	<0.0005[c]
SF-36 MCS[q]	Mean±SD	45.66±9.76	54.40±5.63	71	<0.0005[c]

[a] Chi-square test, [b] SD=standard deviation, [c] Independent-sample t-test, [d] BMI=body mass index, [e] CPB=cardiopulmonary bypass, [f] ISI=Insomnia severity index, [g] IQR=interquartile range, [h] Mann-Whitney U Test, [I] SICQ=Sleep in the Intensive Care Unit Questionnaire, [j] RCSQ=Richards-Campbell Sleep Questionnaire, [k] ICEQ=Intensive care Experience Questionnaire, [l] DASS=Depression Anxiety Stress Scale, [m] PCL-S=Posttraumatic Stress Disorder Checklist for Specific Event, [n] PSQI=Pittsburgh Sleep Quality Index, [o] SF-36=Medical Outcomes Study Short Form-36 Health Survey-Version 2, [p] PCS=physical component summary, [q] MCS=mental component summary

Table 6. Independent associations with sleep quality[a] six months after discharge from hospital

	N	B	Std. Error of B	Beta[b]	P	95% Confidence Interval for B
On-or off-pump	71	1.314	0.917	0.123	0.156	-0.516–3.144
ISI[c] total score	71	0.148	0.050	0.244	0.004	0.048–0.247
SF-36 PCS[d]	71	-0.188	0.038	-0.424	<0.0005	-0.265– -0.111
Sf-36 MCS[e]	71	-0.230	0.042	-0.466	<0.0005	-0.314– -0.146

Adjusted R square=0.547, [a] Dependent variable=total PSQI at six months, [b] Standardised coefficient, [c] ISI=insomnia severity index, [d] PCS=physical component summary, [d] MCS=mental component summary

Table 7. Sleep quality, the experience of treatment in the ICU and psychological outcomes during recovery for patients who had on-pump and off-pump open-heart surgery

		On-pump	Off-pump	N	P
RCSQ[a] in ICU total	Median (IQR[c])	41.40 (18.20-69.20)	36.80 (21.30-65.90)	99	0.99[b]
RCSQ in ward total	Mean±SD[d]	51.64±24.29	51.44±28.81	95	0.97[e]
IECQ[f] Awareness of surroundings	Median (IQR)	37.00 (33.00-41.00)	38.00 (32.00-41.00)	78	0.86[b]
IECQ Frightening experiences	Mean±SD	12.22±5.02	12.11±3.86	78	0.93[e]
IECQ Recall of experiences	Mean±SD	16.68±4.64	18.00±3.87	78	0.27[e]
IECQ Satisfaction with care	Mean±SD	14.75±3.57	14.53±3.41	78	0.81[e]
DASS[g]-21-Depression	Median (IQR)	6.00 (2.00-15.00)	0.00 (0.00-13.00)	71	0.04[b]
DASS-21-Anxiety	Median (IQR)	6.00 (2.00-8.50)	2.00 (0.00-11.00)	71	0.43[b]
DASS-21-Stress	Median (IQR)	8.00 (2.00-14.00)	4.00 (0.00-8.00)	71	0.07[b]
PCL-S[h] total	Median (IQR)	24.00 (21.00-32.00)	19.00 (17.00-26.00)	71	0.02[b]
SF-36[i] PCS[j]	Mean±SD	42.23±10.79	49.61±7.14	71	0.01[e]
SF-36 MCS[k]	Mean±SD	47.79±9.18	52.78±9.38	71	0.06[e]

[a] RCSQ= Richards-Campbell Sleep Questionnaire, [b] Mann-Whitney U Test, [c] IQR=interquartile range, [d] SD=standard deviation, [e] Independent-sample t-test, [f] ICEQ=Intensive care Experience Questionnaire, [g] DASS=Depression Anxiety Stress Scales, [h] PCL-S=Posttraumatic Stress Disorder Checklist for Specific Event, [I] SF-36=Form-36 Health Survey-Version 2, [j] PCS=physical component summary, [k] MCS=mental component summary

Figure legends

Figure 1. Flow chart showing the recruitment and retention of study participants.

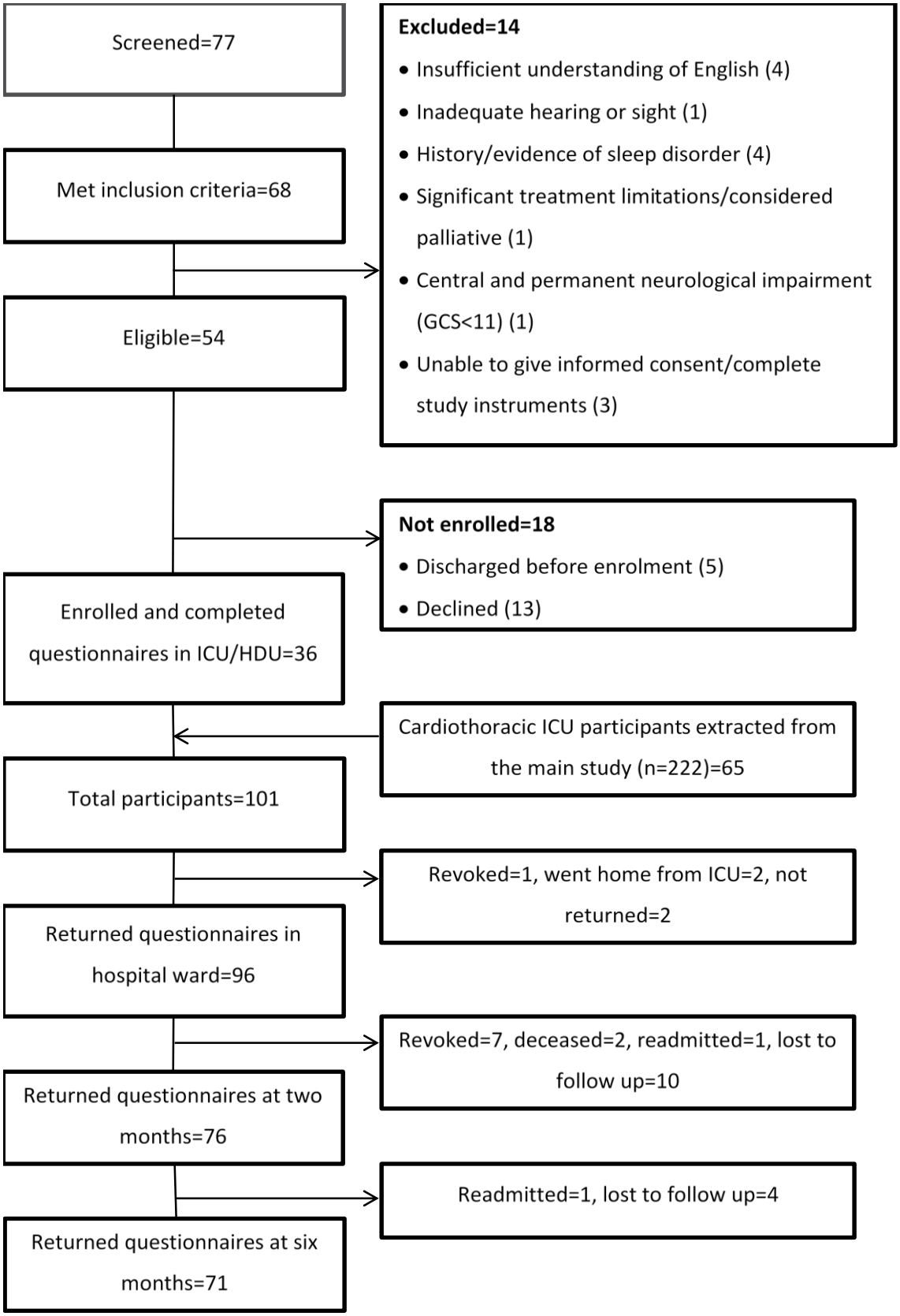

Figure 2. Flow chart showing the recruitment and retention of study participants.