NEMO:

A System for Neonatal Teleconsultation

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Background

Within Queensland, most consultations between remote birth centres and tertiary perinatal facilities are carried out by telephone. Augmenting this process with the addition of real-time visual information at a distance may offer benefits in the management of sick infants. We describe the results of an efficacy and usability evaluation of NEMO (Neonatal Examination and Management Online) – a system for neonatal teleconsultation.

Methods

Experimental setup: The NEMO system comprises a mobile unit (Fig 1) intended for a remote birth centre and a PC based interface (Fig 2) intended for use by clinicians at a tertiary hospital. The tertiary hospital PC interface allows full control of the remote camera functions including pan, tilt, zoom, viewing of high quality real-time images and the capture of stills. For this experiment, the mobile unit was placed adjacent to cots in the Grantley Stable Neonatal Intensive Care Nursery, Royal Brisbane and Women's Hospital, and the controlling PC was situated in a central location within the same nursery. Both components were interconnected by a local area network.

Protocol: To investigate the efficacy of the system for completing infant assessment, ventilated infants were recruited and assessed by medical staff using the system. X-rays were captured both from a traditional light box and from an LCD PACS monitor and reviewed. Assessments included visual examination of the infant and viewing of monitor and ventilator readouts and settings. The System Usability Scale (SUS)2 survey was conducted after each experiment to assess usability.

Control: A consultant neonatologist conducted "in person" infant assessments simultaneously with the teleconsultation assessments. The same staff member also provided the control interpretations of X-rays.

Analysis: Agreement between medical staff participants and control was analysed. For dichotomous variables, exact agreement with control was calculated. For continuous variables, exact agreement with control and agreement within tolerances of 5 and 10 were calculated. Stata 9 (Statacorp, College Station, TX) was also used to calculate weighted Kappa scores for continuous variables. Confidence intervals were found by 1000 bootstrap replications of the dataset. Usability was calculated using the scoring system associated with the SUS.

Results

Feasibility: Initial testing with a mannequin infant was successful. With careful positioning of the camera it was possible to capture very high quality images of a mannequin infant through the two layer plastic wall of the cot[3].

Efficacy: 12 registrars, 3 senior registrars and 3 consultants assessed 8 admitted infants and their first X-ray after admission (captured from a PACS monitor). 298 of 342 tasks (87%) were successfully completed, 13% of tasks could not be completed for various reasons such as camera angle and infant position. A high level of agreement between participants and control was found for infant assessment and for interpretation of the X-ray, for example infant assessment: Respiratory rate 78% within 10 units (resps/min); ETT taped distance 100% with 10 unit (1cm); x-ray interpretation: 83% on ETT position; 94% agreement on heart-size; 88% agreement on normality of lung fields (Table 1). Six X-rays that were representative of past retrievals were also assessed by each participant. 709 of 756 (94%) assessment tasks were successfully completed. In three cases, the participant was unable to assess lung fields. In one case, the participant could not differentiate between the UAC and UVC tip. For completed tasks, a high level of agreement with controls was found (mean 83% across all tasks). Participants rated their confidence with interpreting X-rays using the system highly with a mean confidence rating of 83% across all tasks (Table 2).

Usability: Overall, medical staff found the interface easy to learn and felt confident using the system.5 The mean usability score was 81.7 out of a possible 100 (Table 3).

Conclusions

This work has demonstrated the feasibility, efficacy and usability of a compact, mobile system for neonatal teleconsultation. A multi-centre trial will shortly commence to assess the usefulness of this tool in the management of sick neonates prior to the retrieval team arriving at the referring hospital, a high risk period for outborn infants.

References

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Fig 1

Fig 2

Table 1: Agreement between 18 participants and controls for 342 infant assessment tasks carried out using NEMO

Assessment area	Assessment task	Number of text Completed (%)	Raw agreement with control (%)[1]	Raw agreement within tolerance No. (%)[2]			Weighted Kappa (95% CI)
				0-5	0-10	>10	
Clinical examination	Repiratory rate	18 (100)	2 (11)	10 (56)	14 (78)	4 (22)	0.67 (0.55-0.80)
	Cyanosis	16 (89)	16 (100)				
	Perfusion	13 (72)	12 (92)				
	Morphology	10 (56)	10 (100)				
	ETT taped distance	17 (94)	12(71)	16 (94)	17 (100)	0	0.69 (0.5-0.86)
	NGT taped distance	8 (44)	1 (13)	3 (38)	6 (75)	2 (25)	0.37 (-0.08 - 0.64)
Equipment observation	SaO2	18 (100)	4 (50)	17 (94)	18 (100)	0	0.70 (0.51-0.84)
	Plethysmogram	13 (72)	12 (92)				
	Heart rate	18 (100)	2 (11)	15 (83)	16 (89)	2 (11)	0.70 (0.54-0.84)
	Respiratory rate	15 (83)	1 (7)	7 (47)	8 (53)	7 (47)	0.81 (0.72-0.90)
	ECG	10 (56)	10 (100)				
	Ventilator set rate	18 (100)	15 (83)	17 (94)	18 (100)	0	0.89 (0.73-1.0)
	PIP	18 (100)	17 (94)	18 (100)	0	0	0.97 (0.90-1.0)
	PEEP	18 (100)	18 (100)	0	0	0	0.91 (0.65 - 1.0)
X-ray interpretation	ETT placement	18 (100)	15 (83)				
	Lung fields	17 (94)	15 (88)				
	NGT tip	18 (100)	17 (94)				
	Heart size	17 (94)	16 (94)				
	Other abnormality	18 (100)	17 (89)				
Total		298 (87)[3]	212 (71)				

[1]Number/percentage of assessments that had exact agreement with control values

[2]For continuous measures, the cumulative agreement within tolerances of five and ten units are included (e.g. respiratory rate is respirations/min, heart rate is beats/min etc. For ETT and NGT taped distance, the tolerance is divided by 10 e.g. 5=0.5cm, 10=1.0cm

[3]13% of tasks could not be completed for a range of reasons, e.g. infant/camera position, no tube/lead present etc

Table 2: Agreement between 18 participants and controls with respondents' level of confidence for 756 attempted X-ray assessments made using NEMO

Assessment task	No. tests Completed[1] (%)	Response values	Raw agreement %	Respondents' level of confidence
ETT position	102 (94)	High/Normal/Low	91	84
Lung fields[2]	99 (92)	Normal/Abnormal	81	73
NGT position	102 (94)	Not seen/Stomach/ Other	93	93
Heart size	102 (94)	Normal/Abnormal	84	83
UAC tip[3]	101 (94)	E.g. T6/Not seen	84	89
UVC tip[3]	101 (94)	E.g. T4/Not seen	69	90
Other abnormalities	102 (94)	Yes/No	81	72
Total	709 (94)		83	83

[1]Number/percentage of tests completed. Results from one candidate were disregarded due to incomplete data collection.

[2]In three cases, participants could not assess lung fields citing insufficient image quality

[3]One candidate was unable to differentiate between UAC and UVC tip on one X-ray

Table 3: Usability (SUS) scores for 18 participating medical staff

Participant	SUS Score
1	72.5
2	92.5
3	97.5
4	95.0
5	80.0
6	90.0
7	97.5
8	52.5
9	72.5
10	65.0
11	77.5
12	87.5
13	70.0
14	55.0
15	82.5
16	90.0
17	95.0
18	97.5
Mean	81.7

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