Eur Arch Otorhinolaryngol (2003) 260 : 124–127
DOI 10.1007/s00405-002-0527-1

LARYNGOLOGY

Ryuzaburo Higo · Niro Tayama · Takeshi Watanabe
Takaharu Nito

Pulse oximetry monitoring for the evaluation of swallowing function

Received: 14 January 2002 / Accepted: 31 July 2002 / Published online: 3 October 2002

Abstract The aim of this study was to investigate the relationship between aspiration and oxygen desaturation and to assess the efficacy of using pulse oximetry monitoring as a clinical tool to predict or detect aspiration. The 204 subjects were divided into four groups: 63 control subjects, 110 dysphagics, 9 dysphagics with a cuffed tracheostomy tube and 22 laryngectomized subjects. Arterial oxygen saturation (SpO2) was continuously measured throughout fluorographic examination until an adequate post-examination period afterward. Then, fluorographic findings (aspiration) and SpO2 levels were compared. Eighty-five percent of aspirators showed SpO2 declines of 2% or more during swallowing procedures, but, conversely, aspiration could not be predicted or detected by an SpO2 decline because of low sensitivity and specificity (84.6% and 82.5%, respectively). SpO2 declines were also seen in laryngectomized subjects and non-aspirators with breath-holding. One patient with a cuffed tracheostomy tube showed a transient elevation of SpO2 following aspiration. In conclusion, aspirators show a SpO2 decline during swallowing procedures, but POM is not useful to predict or detect aspiration. Other events, such as breath-holding, posture change, coughing and compromised pulmonary functioning, may be related to oxygen desaturation.

Keywords Dysphagia · Arterial oxygen saturation (SpO2) · Pulse oximetry · Aspiration · Videofluorography

Introduction

Pharyngeal swallowing of dysphagic patients has so far been evaluated by videofluorography (VF) or videoendoscopy (VE) [1, 5, 7]. While highly useful, VF and VE have some disadvantages. As to VF, these include X-ray radiation, transferring the patient to the examination room, the initial cost for introducing the system, etc. Although VE is superior to VF in that no radiation is involved and it is transportable to the bedside, VE has other disadvantages: patients must have an endoscope inserted through the nose, and VE has the problem of a "white-out period." As alternatives to VF or VE, other methods for screening and/or assessing dysphagia, such as cervical auscultation [12] or pulse oximetry [10, 11], have recently been introduced.

Pulse oximetry monitoring (POM) provides accurate, noninvasive and uninterrupted data. The cost is low, and the equipment is easy to handle. Therefore, POM has attracted the increased attention of investigators as a clinical tool at the bedside. However, the efficacy of using POM to predict or identify aspiration is still controversial. Some reports suggested that POM can predict aspiration [2, 8, 11], but others insisted aspiration did not change SpO2 values and doubted the efficacy of using POM as a diagnostic tool to predict or identify aspiration [3, 4, 6, 9].

The aim of this study was to investigate the relationship between aspiration and oxygen desaturation in a large sample, including a control group, by monitoring arterial oxygen saturation during fluorographic swallowing evaluation, and to assess the efficacy of using POM as a clinical tool to predict or identify aspiration.

R. Higo (✉) · N. Tayama · T. Watanabe · T. Nito
Department of Otolaryngology, Faculty of Medicine,
University of Tokyo, 3-1, Hongo 7-chome,
Bunkyo-ku, Tokyo 113-8655, Japan
e-mail: rhigo-tky@umin.ac.jp,
Tel.: +81-3-58008665, Fax: +81-3-38149486

Materials and methods

Two hundred and four subjects who underwent VF participated in this study. They were divided into four groups (Table 1), as follows.

Group 1 (the control group) consisted of 63 subjects who did not suffer from swallowing disorder but needed a fluorographic study in screening for esophageal diseases, such as tumors.

Group 2 consisted of 110 subjects who showed symptoms related to dysphagia and were evaluated for swallowing function by VF. The causes of swallowing dysfunction were cerebrovascular disease, neuromuscular disease, head and neck tumor and others (Table 2).

Table 1 Demographics. (*Group 1* control group, *group 2* patients who showed symptoms related to dysphagia, *group 3* dysphagic patients with a tracheostomy, *group 4* patients who had received a laryngectomy)

	Cases	Age (mean)
Group 1		
Male	38	26–85 (57.2)
Female	25	24–81 (57.5)
Group 2		
Male	78	19–91 (62.6)
Female	32	25–86 (59.4)
Group 3		
Male	8	30–59 (51.4)
Female	1	25
Group 4		
Male	19	50–78 (64.5)
Female	3	62–78 (68.0)

Table 2 Diseases of the patients in groups 2 and 3. (*CVD* cerebrovascular disease)

	Group 2	Group 3
CVD or brain tumor	13	4
Neuromuscular disease	20	1
Head and neck tumor	22	2
Laryngeal paralysis	17	0
Laryngeal trauma	4	1
Others	34	1
Total	110	9

Group 3 consisted of nine subjects with the same problems as group 2 (Table 2); however, they differed in having received a tracheostomy and in their use of a cuffed tracheostomy tube. These patients were separated from group 2 to assess the influences and effects of the cuffed tracheostomy tube.

Group 4 consisted of 22 subjects who had each received a laryngectomy. They were included in this study to search for other factors causing oxygen desaturation in the absence of aspiration.

Continuous arterial oxygen saturation (SpO2) data, collected at 10-s intervals, were obtained using a Pulse Oximeter (PULSOX-3Li; Minolta Co., Ltd., Tokyo). An adequate preparation period (more than 1 min) was introduced to establish a baseline SpO2 level. Following measurement of the baseline SpO2 level, VF was performed. Appropriate and safe bolus textures (thin liquid, thick liquid or paste) and bolus volumes (3 ml, 5 ml or self-regulated) were used in each subject. SpO2 was continuously measured throughout the fluorographic examination until an adequate post-examination period (minimum of 1 min) afterward. The lowest SpO2 level was identified from the data record. Examination of three viewing planes (anteroposterior, lateral and right anterior oblique position) was adopted in our protocol, and the posture of patients was basically standing or sitting upright.

Results

The mean±SD of baseline SpO2 levels, the lowest SpO2 levels and SpO2 declines in each group are shown in Table 3. There were no significant differences in baseline SpO2 levels, the lowest SpO2 levels and SpO2 declines between group 1 (the control group) and any of the other groups.

Table 3 Results of baseline SpO2 levels, the lowest SpO2 levels and SpO2 declines in each group

	Baseline SpO2 (mean±SD)	Lowest SpO2 (mean±SD)	SpO2 decline (mean±SD)
Group 1	96.9±1.1	95.8±1.7	1.0±1.4
Group 2	96.9±1.2	95.5±3.2	1.4±2.8
Group 3	97.1±0.6	95.0±2.3	2.1±2.4
Group 4	97.0±1.0	96.1±2.3	0.9±2.1

Table 4 Baseline SpO2 levels, the lowest SpO2 levels and SpO2 declines in aspirators of group 2. (*ALS* amyotrophic lateral sclerosis, *H&N T* head & neck tumor, *CVD* cerebrovascular disease)

		Baseline SpO2	Lowest SpO2	SpO2 decline
1	ALS	98	98	0
2	H&N T	96	96	0
3	H&N T	96	94	2
4	CVD	97	95	2
5	H&N T	97	95	2
6	H&N T	96	93	3
7	Laryngeal trauma	97	93	3
8	H&N T	97	93	4
9	H&N T	97	93	4
10	H&N T	93	88	5
11	Laryngeal paralysis	100	95	5
12	Parkinson	94	80	14
13	Parkinson	96	81	15
	Mean (SD)	96.5 (1.7)	91.9 (5.6)	4.5 (4.7)

Aspiration was not seen in any patients in group 1, while it was seen in 13 patients (11.8%) in group 2. Table 4 shows detailed data of baseline SpO2 levels, the lowest SpO2 levels and SpO2 declines of each aspirator. The means±SD of baseline SpO2 levels and the lowest SpO2 levels of aspirators were 96.5±1.7 and 91.9±5.6, respectively. There was no significant difference between the baseline SpO2 levels of group 1 and those of the aspirators in group 2 (Mann-Whitney U-test; P=0.20), but there was a significant difference between the lowest SpO2 levels of group 1 and those of the aspirators in group 2 (Mann-Whitney U-test; P<0.001).

Figure 1 shows the number of subjects at each SpO2 decline in group 2. Fifty-seven cases in group 2 showed no changes in their SpO2 levels. Three cases, with respectively 7%, 11% and 15% declines in SpO2, did not aspirate, while two cases with no changes in SpO2 levels aspirated (Fig. 1). Sensitivity and specificity of aspiration, calculated based on a 2% drop in SpO2 as the cutoff point, were 84.6% and 82.5%, respectively. When the cutoff point was changed to a 3% drop, sensitivity decreased to only 61.5%. No matter what cutoff point is adopted, sensitivity and specificity are insufficient to use POM as a diagnostic tool to predict or identify aspiration.

In group 3, aspiration was seen in three cases, and their respective SpO2 declines were 0%, 4% and 7% (Table 5). One of them showed a transient SpO2 elevation after aspiration, but a 4% SpO2 decline occurred soon after the elevation.

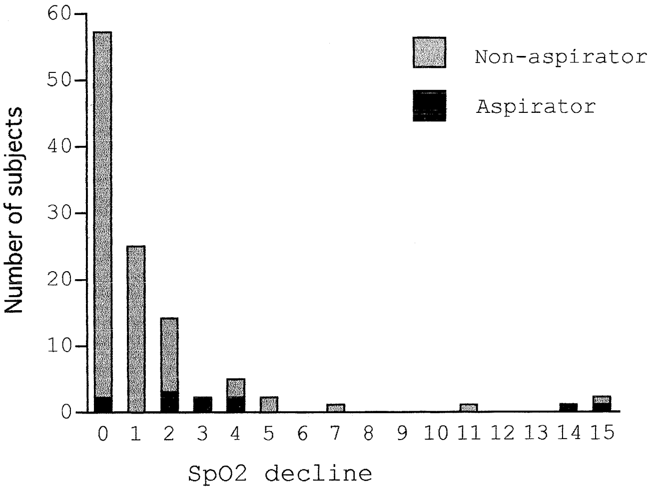

Fig. 1 The number of subjects at each SpO2 decline in group 2

Table 5 Baseline SpO2 levels, the lowest SpO2 levels and SpO2 declines of nine subjects in group 3. Case 8 showed a transient 2% SpO2 elevation after aspiration, but the SpO2 level dropped to 93% soon after the elevation. (*H&N T* head & neck tumor, *CVD* cerebrovascular disease)

		Baseline SpO2	Lowest SpO2	SpO2 decline	Aspiration
1	Brain tumor	98	98	0	+
2	H&N T	97	97	0	–
3	Myasthenia gravis	97	97	0	–
4	Larygeal trauma	98	97	1	–
5	CVD	97	96	1	–
6	H&N T	98	95	3	–
7	Bulbar palsy	97	94	3	–
8	CVD	97	93	4	+
9	Brain tumor	97	90	7	+

Table 6 Baseline SpO2 levels, the lowest SpO2 levels and SpO2 declines of five laryngectmized subjects that showed 2% or more SpO2 declines in group 4. (*H&N T* head & neck tumor, *ALS* amyotophic lateral sclerosis)

		Baseline SpO2	Lowest SpO2	SpO2 decline
1	H&N T	96	94	2
2	H&N T	96	94	2
3	H&N T	97	95	2
4	H&N T	96	92	4
5	ALS	98	89	9

The mean±SD of the baseline and the lowest SpO2 levels in group 4 were 97.0±1.0 and 96.1±2.3, respectively (Table 3). Most of them showed stable SpO2 levels. In group 4, 15 cases showed no changes in SpO2 levels, and two other cases showed 1% drops in SpO2. However, even though aspiration did not occur in this group, five cases showed SpO2 declines of 2% or more (Table 6).

Discussion

This study demonstrated that 84.6% of aspirators showed SpO2 declines of 2% or more. However, this did not imply that aspiration directly caused oxygen desaturation. In fact, patients who aspirated during the examination showed SpO2 declines of 2% or more during the swallowing procedure (swallowing and post-swallowing periods). Other events followed by aspiration, such as a posture change or coughing, or even just performing swallowing, may be related to oxygen desaturation [6].

Although aspirators showed SpO2 declines, the opposite is not always true. Sensitivity and specificity of POM for predicting or identifying aspiration are quite insufficient. According to Sellars et al., 4% variation has been internationally accepted as the criterion for an abnormal SpO2 decline [9]. Sensitivity is only 46.2% when the cutoff point is set as a 4% SpO2 decline in this study. Collins and Bakheit chose a 2% criterion [2], but even with the cutoff point set at 2%, SpO2 decline, sensitivity is 84.6%, and specificity is only 82.5%. Therefore, aspiration cannot be predicted or detected only by oxygen desaturation data obtained from POM.

Colodny reported no dramatic changes in SpO2 during or after swallowing, or during episodes of aspiration [3, 4]. The finding is consistent with the conclusion of Sellars et al. [9]. In contrast, Zaidi et al. reported that desaturation occurred among aspirating patients [11]. Collins and Bakheit also found that they could predict aspiration with 81.5% accuracy using a criterion of an SpO2 decline of 2% or more among dysphagic stroke patients [2]. In our study, the conclusion is that aspirators practically show an SpO2 decline during swallowing procedures, but that aspiration cannot be predicted or identified by POM.

Interestingly, one patient with a cuffed tracheostomy tube demonstrated a transient elevation of SpO2 after aspiration. This patient, however, showed a 4% SpO2 decline. VF for this patient demonstrated that a penetrated bolus stimulated the trachea and caused labored respiration. Saturation temporarily elevated as a result. The blocking effect of the cuff kept SpO2 from declining at first. However, overloaded retention of the penetrated bolus exceeded the blocking effect of the cuff. It finally entered the lower portion of the trachea. This phenomenon implies that careful attention is required to assess the data of patients with a tracheostomy tube.

Five cases without aspiration in group 4 showed SpO2 declines of 2% or more. A patient who showed a 9% decline in SpO2 had amyotrophic lateral sclerosis (ALS) and underwent a laryngectomy to prevent recurrent aspiration pneumonia and death. Even after the operation, she held her breath during each swallow, and SpO2 was gradually decreased with repeated breath-holding. She confessed that she remained frightened of choking and unconsciously held her breath. The same phenomenon was also seen in some patients of group 2. Four patients, who did not show aspiration but did have abnormal SpO2 declines, held their breath during the examination. Therefore, besides aspiration, breath-holding was an important factor causing an SpO2 decline. Leder discussed that posture, swallowing or coughing is likely to influence SpO2 levels [6]. Colodny concluded that dysphagics' respiratory systems are already compromised and that dysphagics already have lower SpO2 levels than nondysphagics [3, 4]. Therefore, posture, swallowing, coughing, compromised pulmonary functioning and breath-holding are possible factors affecting SpO2 levels. We emphasize that the data of POM should be carefully assessed in various aspects, including aspiration.

Acknowledgement This research was supported by Comprehensive Research on Aging and Health (H11-Choju-035) from Health Sciences Research Grants.

References

1. Bastain RW (1993) The videoendoscopic swallowing study: an alternative and partner to the videofluoroscopic swallowing study. Dysphagia 8: 359–367
2. Collins M, Bakheit A (1997) Does pulse oximetry reliably detect aspiration in dysphagic stroke patients? Stroke 28: 1773–1775
3. Colodny N (2000) Comparison of dysphagics and nondysphagics on pulse oximetry during oral feeding. Dysphagia 15: 68–73
4. Colodny N (2000) Effects of age, gender, disease, and multisystem involvement on oxygen saturation levels in dysphagic persons. Dysphagia 16: 48–57
5. Langmore SE, Schatz K, Olson N (1991) Endscopic and videofluoroscopic evaluations of swallowing and aspiration. Ann Otol Rhinol Laryngol 100: 678–681
6. Leder SB (2000) Use of arterial oxygen saturation, heart rate, and blood pressure as indirect objective physiologic markers to predict aspiration. Dysphagia 15: 201–205
7. Logemann J (1983) Evaluation and treatment of swallowing disorders. College-Hill Press, San Diego
8. Rogers B, Msall M, Shucard D (1993) Hypoxemia during oral feedings in adults with dysphagia and severe nuerological disabilities. Dysphagia 8: 43–48
9. Sellars C, Dunnet C, Carter R (1998) A preliminary comparison of videofluorography of swallow and pulse oximetry in the identification of aspiration in dysphagic patients. Dysphagia 13: 82–86
10. Sherman B, Nisenboum JM, Jesgerger BL, Morrow CA, Jesberger JA (1999) Assessment of dysphgia with the use of pulse oximetry. Dysphagia 14: 152–156
11. Zaidi NH, Smith HA, King SC, Park C, O'Neill PA, Conolly MJ (1995) Oxygen desaturation on swallowing as a potential marker of aspiration in acute stroke. Age Ageing 24: 267–270
12. Zenner PM, Losinsky DS, Russel HM (1995) Using cervical auscultation in the clinical dysphagia examination in long-term care. Dysphagia 10: 27–31