Over Seven Years of Experience with an Automated Subglottic Aspiration System in a Comatose Patient with Traumatic Brain Injury

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Abstract

Beginning in January 2010, a comatose traumatic brain injury patient with severe neurogenic dysphagia was the first patient treated with an Automated Subglottic Aspiration System (ASAS). The system was designed to aspirate saliva and oropharynx secretions from above the ballooned cuff of a permanently blocked tracheal cannula. Since the patient's initial injury from a severe fall in 2006, the goal was to reduce the large amounts of saliva and secretions leaking out of the tracheostoma, which previously had been collected with materials such as towels and compress sponges, by using manual suction with syringes, and by using conventional suction pumps. Prior to using the new system, the patient's clothing, linens, and dressings had to be changed and other tracheostomy care procedures had to be repeated multiple times per day. The massive amount of paratracheal leakage was a major obstacle to treatment for improving the swallowing reflex, and put the patient at risk of developing aspiration pneumonia, which can result from secretions leaking into the lungs. For the first time, the ASAS made automated aspiration possible 24/7, and combined the capabilities to variably and precisely control suction pressure, duration, and frequency. The aspiration device was attached to the subglottic port of a tracheal cannula via a suction tube. After a few weeks of use, approximately 300ml of saliva and secretions were collected daily as compared to approximately 25ml with the use of the syringe. Nursing time was reduced to average levels, and the consumption of dressings and other tracheostomy supplies was greatly reduced. The patient's vital signs and swallowing reflex further improved under the clean and dry conditions. The comatose patient was able to comfortably tolerate continuous use of the ASAS for a total of 7.5 years (90 months), until the time of his death. The experience gained in this case has important positive implications for improving patient quality of life, for preventing aspiration pneumonia and potential cross contaminations, for improving staff conditions and quality of care, and for reducing the use of materials and other resources, and their staggering costs.

Introduction

In the case highlighted here, the patient, Mr Brunner (name changed), suffered a traumatic brain injury (TBI), after a severe stair fall in 2006. In the acute care hospital he was tracheostomized, to address a long and continuing need for mechanical ventilation. He showed no reaction to external stimuli, and only facial tactile stimuli could occasionally raise the tone and grimaces. Communication attempts by Mr Brunner were not observed.

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Upon admission to our long-term rehabilitation unit in Nuremberg, the patient remained comatose, but was no longer in need of continuous ventilation. His condition did not permit decannulation, however, because of severe dysphagia with massive salivation and secretions. From time to time, between stable respiratory phases, he exhibited respiratory insufficiency and periodically required additional mechanical ventilation.

After a few months of logopedic therapy, swallowing reactions were barely stimulated during the clinical swallowing examination. The swallowing frequency was greatly impaired and swallowing quality was ineffective. Protective reactions such as coughing were reflexive, delayed, impaired and ineffective. The lack of clearance features and massive paratracheal sputum leakage indicated a severe disturbance of sensitivity in the pharynx and laryngeal areas.

For much of the next four years, suctioning was conducted manually using syringes or other available suction devices. The introduction of tracheal tubes with subglottic suction ports for suctioning above the cuff offered promise, but techniques and suction pressures varied among caregivers, resulting in suboptimal aspiration and potential mucous membrane tissue irritation. The moist environment in the area of the stoma continued to be the cause of severe skin lesions. The clothing and even the bedding of the patient were always wet to moist, and quickly developed a foul odor and potential for cross contamination (See Figures 1-3). Endotracheal aspiration had to be conducted as many as 17-20 times per day. In January 2010, treatment with the Automated Subglottic Aspiration System (ASAS) was initiated (See Figure 4).

> "[Prior to use of the ASAS] The clothing and even the bedding of the patient were always wet to moist, and quickly developed a foul odor and potential for cross contamination."

The aspiration system was attached to the tracheal cannula via a subglottic port, every day for 24 hours, to aspirate above the cuff intermittently, around the clock. The system allowed for control of suction pressure, frequency, and interval. Various combinations of parameter settings were tried, as well as

various tracheostomy tubes. Among the various tubes trialed, the Portex Blueline Ultra Suctionaid (Size 8) was considered the best fit for the patient. The system developer, Helmut Fendler of Gesundheits Manager GmbH, Nuremberg, Germany, closely monitored the secretion volumes collected.[1] When relatively low ASAS negative pressures were applied, initial volumes collected were low, approximately 15 ml/day, and the stoma remained moist and extremely red.

> "[Prior to the use of the ASAS] endotracheal aspiration initially had to be conducted as many as 17-20 times per day."

A breakthrough in Mr Brunner's case resulted with an ASAS pressure setting of -200 mbar (-150 mmHg), suction time of 18 seconds, and suction interval of 5 minutes (See Figure 5). After 4 days the collection canister accumulated 1000ml of secretions and the stoma was dry because there was no more overflow of secretions. After 6 additional days and an additional 1900 ml of secretions had been aspirated, the skin condition in the stoma area further improved (See Figure 6). Two years after the first use of the ASAS, daily secretions collected stabilized at almost 60 ml per day, and Mr Brunner's stoma remained dry and clean (See Figures 7-8). By the time of his death in June 2017, he had been maintained successfully on the aspiration system for 7.5 years (90 months).

> "After a few weeks of initial use and fine tuning [of the aspiration system], approximately 300ml of saliva and secretions were collected daily."

The reduction in the volume of sputum and secretions collected, from 300ml daily initially, to 60ml daily after two years, were in part attributed to steady improvements in oropharyngeal sensitivity, which allowed the secretions to be recognized and swallowed. The 24/7 aspiration and gentle stimuli provided by the ASAS, were thought to have contributed to the gradual improvements in the swallowing reflex.

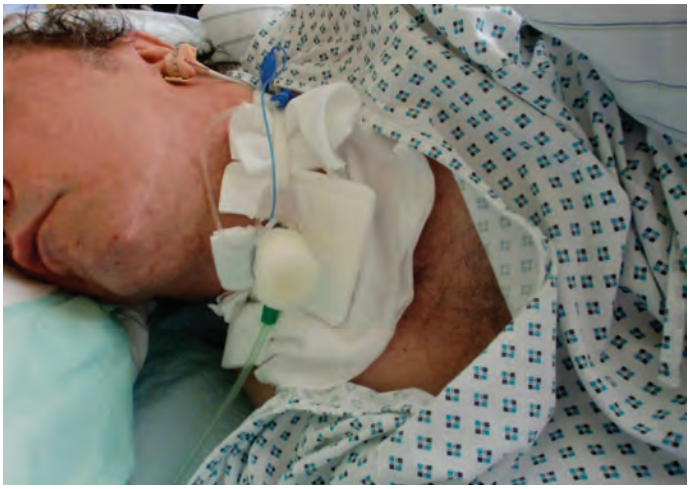

Figure 1. Intensive tracheostoma care required due to excessive secretion production and paratracheal leakage prior to use of ASAS.

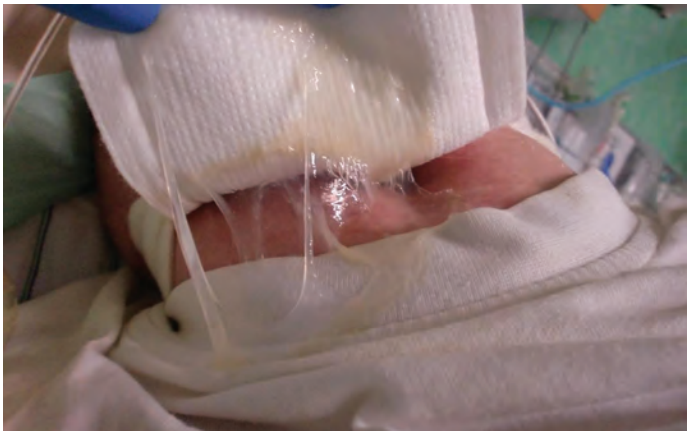

Figure 2. Leaking paratracheal secretions before introduction of the ASAS.

Figure 3. Syringe (20 ml) used to aspirate secretions from subglottic port of tracheal tube.

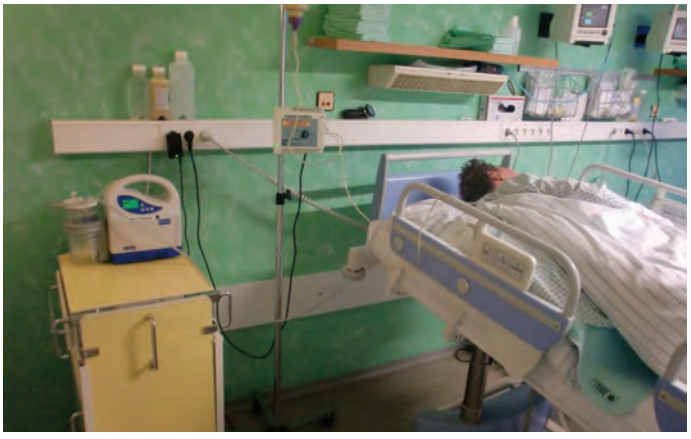

Figure 4. Simex Automated Subglottic Aspiration System (ASAS) at bedside.

Discussion

In caring for patients with traumatic brain injury (TBI), the goals of the therapeutic team are to wean the patient from mechanical ventilation, to prevent life-threatening infections, to restore pharyngeal sensitivity and the swallowing reflex, and to help the patient, where possible, regain the ability to speak following decannulation. Equally important, as in the case of Mr Brunner, the automated subglottic aspiration system greatly improved his comfort and quality of life, as well as many other aspects of his

Figure 5. ASAS settings at -200 mbar, aspiration time 18 seconds, aspiration interval 5 minutes.

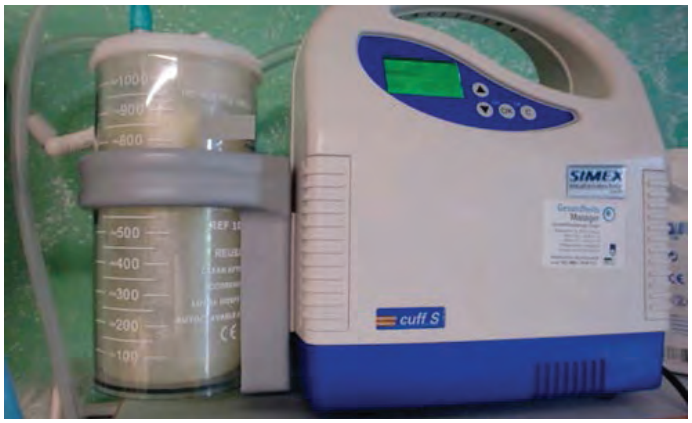

Figure 6. 900ml of sputum aspirated after 3 days.

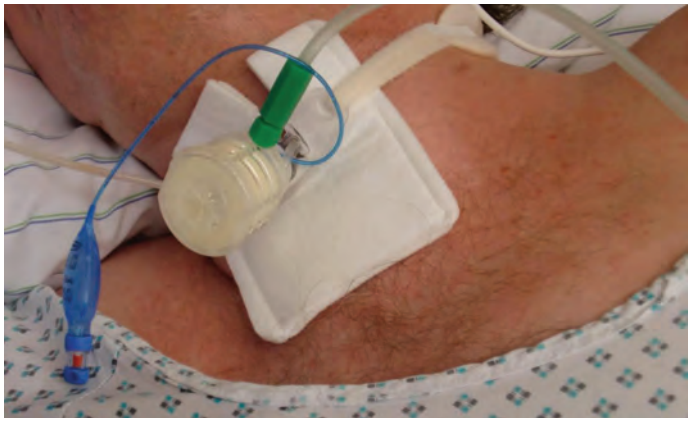

Figure 7. Tracheostoma care with trach slit dressing used with automated subglottic aspiration system.

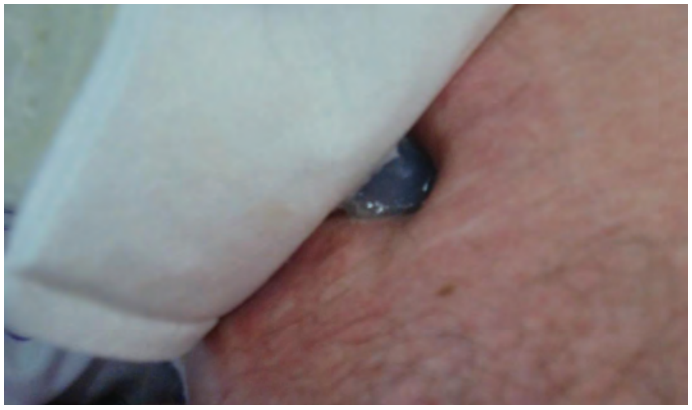

Figure 8. Dry tracheostoma after use of ASAS system.

care and care setting, despite the patient's comatose condition for the entire period of 7.5 years he was supported by the aspiration system.

The patient only required mechanical ventilation from time to time while in our long-term care facility. There were no differences between ventilated and non-ventilated periods with regard to the efficiency of the ASAS, the parameter settings or the aspirated secretion volumes.

Despite his limited need for mechanical ventilation while in our facility, Mr Brunner's case has far-reaching positive implications for mechanically ventilated patients and others requiring temporary or permanent use of a blocked cannula. Among this patient population, ventilator-associated pneumonia (VAP), and ventilator-associated events (VAE), remain leading causes of death and readmissions to intensive care units, and contribute to antibiotic resistance.[2] This case represented the first use of the ASAS in a long-term care setting. Additional experience with the ASAS in a long-term care setting was gained in the US, beginning in 2015.[3-5] In 2016, Wolf reported extensive experience with the ASAS in an ICU facility in Hamburg, Germany.[6]

Gradual increases in the frequency of deblocking of the trachea are required to improve the swallowing reflex and improve clearance functions,[7-8] but increases in deblocking times are associated with high risk. If infected secretions descend into the lower respiratory tract, they result in increases in bronchopneumonia rates.[9-11]

Now known commercially as the Simex Automated Subglottic Aspiration System (ASAS), the system is programmable to address both the volume and viscosity of secretions. Negative pressure settings range from -60 to -300 mbar (-45 to -225 mmHg), with intervals ranging from 10-60 seconds (ON), and from 3-60 minutes (PAUSE). The aspiration system operates both quietly and gently. The system helps prevent the tracheal tissue damage associated with manual suctioning via syringe. Depending on syringe size and volume, a syringe puts -578 to -722 mmHg of force on the airway.[12] AARC guidelines recommend the use of negative pressures from -80 to -150mmHg.[13]

Over the course of Mr Brunner's treatment, experience with the system was gained and adjustments were made, based on changes in medication, tracheal cannula management, dysphagia-related functional improvements or dysfunctions, and potential infections. All these factors influenced the amount and nature of the aspirate. In addition to the removal of secretions, it was observed that use of the ASAS system had a positive effect on the swallowing frequency as well as the swallowing effectiveness, made apparent by the reduction of secretions collected to 60ml per day, from the original 300ml per day.

> "Savings associated with use of the ASAS device, in this case alone, amounted to…€392,692.50…over the entire 7.5 years."

Despite initial skepticism, all of the health professionals involved in the care of Mr Brunner—nurses, speech therapists, and physicians, were "amazed" at the amount of secretions/sputum removed. From the start of logopedic therapy to improve the

swallowing reflex, use of the system permitted deblocking of the trachea once an hour, versus zero times per hour previously.

The frequency of stoma care, and the amount of consumables used dropped dramatically with the use of the ASAS aspiration system. The need for tracheostoma care dropped from 14 times a day, to 2-3 times daily. The need for endotracheal aspiration dropped from 17-20 times a day, to 5-7 times daily. The time saved allowed staff members to focus on other important patient-related activities.

The reduced need and frequency of care procedures had a tremendous impact on the need for consumables. The results are quantified and presented in Figure 9. Savings associated with use of the ASAS device, in this case alone, amounted to €1,007.00 for one week; which extrapolates to €52,359.00 for one year; and €392,692.50 in savings over the entire 7.5 years (See Figure 10). Device-related costs were €1,314 per year (or total of €9,857 during 7.5 years), generating over €50,000 in annual net savings.

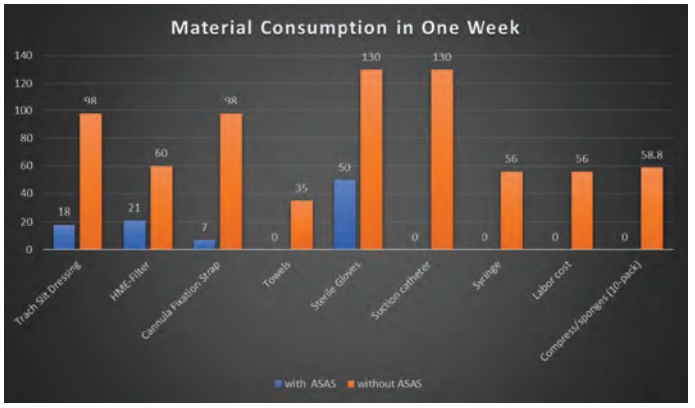

Figure 9. Weekly material savings after utilization of ASAS.

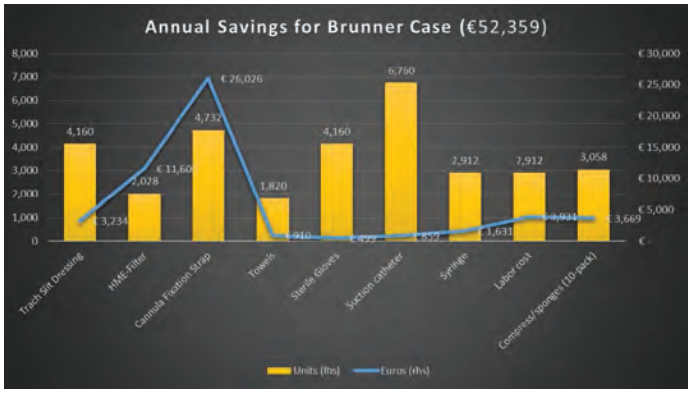

Figure 10. Device related savings were €52,359 per year. Device-related costs were €1,314 per year, generating over €50,000 in annual net savings.

Conclusion

The long-term case of coma patient, Mr Brunner, illustrates the many benefits associated with the use of an Automated Subglottic Aspiration System (ASAS). Following treatment, the patient's quality of life improved greatly. His stoma was kept clean and dry, he was made comfortable, and had healthy skin, without odor and stigma. In combination with comprehensive, high quality care, he was protected from infection and from contaminating others. Use of the system in this individual patient over 7.5 years dramatically reduced the quantity of consumables used in his care, improved the clinical environment, saved countless numbers of staff hours, and saved hundreds of thousands of Euros.

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