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SPINAL CORD INJURY REHABILITATION EVIDENCE

Bowel Dysfunction and Management Following Spinal Cord Injury

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Key Points

There is limited and conflicting evidence in support of multifaceted bowel management programs for managing neurogenic bowel dysfunction.

There is a need for further research to examine the optimal level of dietary fibre intake in patients with SCI.

Digital rectal stimulation increases motility in the left colon in individuals with reflex neurogenic bowel dysfunction after SCI.

Digital evacuation of stool is a very common intervention for bowel management after SCI, reducing duration of bowel management and fecal incontinence.

There is contrasting evidence on the effectiveness of abdominal massage in treating neurogenic bowel dysfunction. Further research is needed.

Electrical stimulation of the abdominal wall muscles can improve bowel management for individuals with tetraplegia.

Functional magnetic stimulation may reduce colonic transit time in individuals with SCI.

Sacral anterior root stimulation reduces severe constipation in individuals with SCI.

Transanal irrigation can improve all bowel management outcomes in individuals with chronic neurogenic bowel dysfunction following SCI.

The Malone Antegrade Continence Enema is a safe and effective treatment for significant GI problems in persons with SCI when conservative and transanal irrigation are unsuccessful or inappropriate.

Pulsed water transanal irrigation may help to remove stool in individuals with SCI.

In very small studies prucalopride, metoclopramide, neostigmine, and fampridine have been found to improve constipation in individuals with SCI.

Prucalopride is not currently available the United States but is available in Canada and Europe. More research is required on prokinetic agents prior to their regular use in neurogenic bowel dysfunction.

Polyethylene glycol-based bisacodyl suppositories (10 mg.) are more effective in stimulating reflex evacuation as part of abowel management program in persons with an upper motor neuron SCI than bisacodyl in vegetable oil suppositories.

Elective stoma formation is a safe and effective treatment for significant neurogenic bowel management problems and perianal pressure ulcers in persons with SCI, and greatly improves their quality of life.

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Abbreviations

ACE	Antegrade Colonic Enema
DIE	Difficult Intestinal Evacuation
DGN	Dorsal Genital Nerve
FES	Functional Electrical Stimulation
FMS	Functional Magnetic Stimulation
GE	Gastric Emptying
GI	Gastrointestinal
HVB	Hydrogenated Vegetable-oil Base
LMN	Lower Motor Neuron
MACE (or ACE)	Malone Antegrade Continence Enema
NBD	Neurogenic Bowel Dysfunction
PGB	Polyethylene Glycol Base
SARS	Sacral Anterior Root Stimulator
SNM	Sacral Nerve Modulator
SNS	Sacral Nerve Stimulation
TAI	Transanal Irrigation
UMN	Upper Motor Neuron

Bowel Dysfunction and Management Following Spinal Cord Injury

1.0 Introduction

Bowel dysfunction due to spinal cord injury (SCI) results in fecal incontinence and severe constipation termed 'neurogenic bowel dysfunction' (NBD) and is very damaging to quality of life (Emmanuel 2010; Byrne et al. 2002; Correa & Rotter 2000; Stiens et al. 1997; Glickman & Kamm 1996; Longo et al. 1995).

Even when a bowel routine to manage the problem is effective it can be onerous and time consuming, and may take up to 1-2 hours per session, repeated every day or alternate days throughout post-injury life. It can interfere significantly with the individual's education, work and social life and presents a major challenge to quality of life, independence and community reintegration after SCI. Loss of bowel control may have greater impact than loss of ability to ambulate (Frost et al. 1993) and is a source of anxiety and distress (Ng et al. 2005; Glickman & Kamm 1996; Coggrave et al. 2009; Coggrave & Norton 2010). Ineffective bowel care results in social isolation (Byrne et al. 2002), inability to work and admissions to acute services for treatment of fecal impaction and bowel obstruction when constipation escalates. Treatment of bowel dysfunction rates highly for patients in both clinical and research domains (Anderson 2004; Glickman & Kamm 1996).

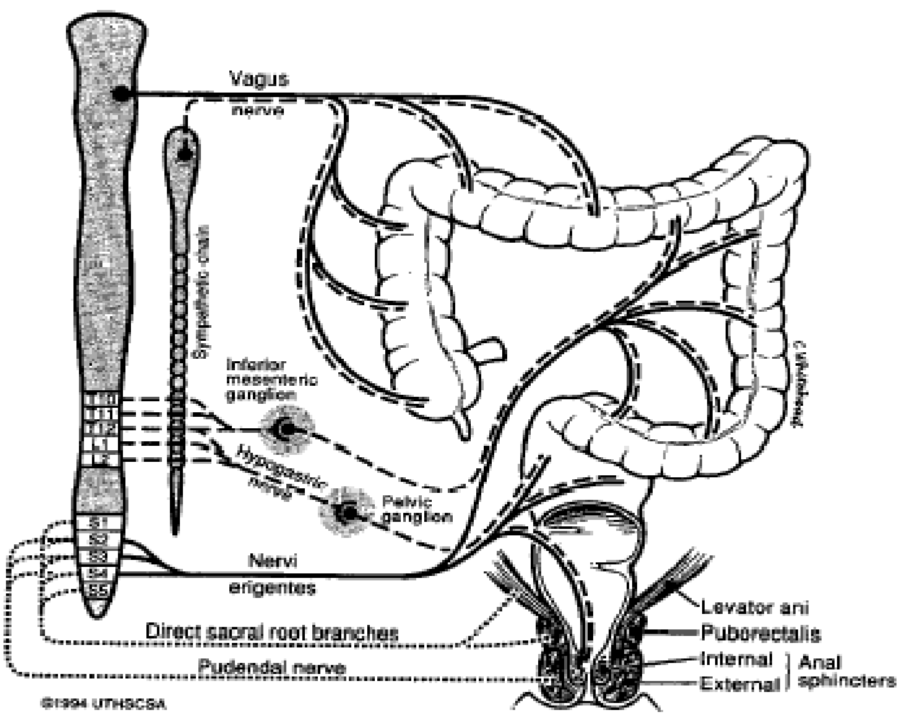

Figure 1: [1] Innervation of the gastrointestinal (GI) system. Schematic diagram of the autonomic and somatic innervations of the lower GI tract and pelvic floor. The brainstem, spinal cord and sympathetic chain are shown on the left, and the colon, rectum and pelvic floor on the right. Sympathetic innervation (dashed lines) originates from the thoracic and upper lumbar regions; parasympathetic innervation (solid lines) orginates from the vagus nerve (to the upper GI and colon up to the colonic flexure) and from the sacral region of the spinal cord (to areas below the splenic flexure). Dotted lines represent the mixed nerves supplying the somatic innervation to the musculature of the external anal sphincter and the pelvic floor.

[1] Reprinted from Archives of Physical Medicine and Rehabilitation, 78(3), Steins SA, Biener Bergman S, Goetz LL, Neurogenic bowel dysfunction after spinal cord injury: clinical evaluation and rehabilitative management, S86-S102, Copyright (1997), with permission from Elsevier.

2.0 Neurogenic Bowel Dysfunction and Management

Disrupted autonomic control of the gastrointestinal (GI) tract is the primary cause for neurogenic bowel dysfunction, leading to delayed gastric emptying (Leduc et al. 2002; Gondim et al. 2001; Menter et al. 1997; Rajendran et al. 1992; Fealey et al. 1984) and poor colonic motility (Lynch & Frizelle 2006; Fajardo et al. 2003). This results in prolonged bowel transit time (Brading & Ramalingam 2006; Krogh et al. 2000; Nino- Murcia et al. 1990; Lynch et al. 2001), constipation (Faaborg et al. 2008; Finnerup et al. 2008; Lynch et al. 2000), and postprandial (after eating a meal) abdominal distension (Stone et al. 1990a). Left unmanaged, individuals with neurogenic bowel dysfunction will experience profound constipation and fecal impaction as effective spontaneous evacuation does not occur. In addition, lost or impaired anorectal sensation and voluntary motor control lead to unpredictable feacal incontinence. The neurogenic changes are compounded by reduced mobility, polypharmacy and poor dietary intake. Furthermore, bowel dysfunction following SCI is associated with episodes of autonomic dysreflexia (Furusawa et al. 2007; Cosman and Vu 2005).

The colon and anorectum are innervated by the sympathetic and parasympathic autonomic nervous system with somatic innervation to the external sphincter as shown in **Figure 1**. In addition the gastrointestinal tract has an enteric nervous system divided into the submucosal (Meissner's) and myenteric (Auerbach's) plexuses. The enteric system controls gut secretions, blood flow and muscular activity giving the colon its inherent ability to produce peristalsis. While the autonomic and somatic neural input is disrupted in SCI, the enteric system remains intact.

Depending on the level of injury, there are two distinct patterns in the clinical presentation of bowel dysfunction: injury above the conus medullaris results in upper motor neuron (UMN) bowel syndrome while injury at the conus medullaris and cauda equina results in lower motor neuron (LMN) bowel syndrome (Singal et al. 2006; Steins et al. 1997).

The upper motor neuron bowel, or hyperreflexic bowel, is characterized by increased colonic wall and anal tone. Voluntary (cortical) control of the external anal sphincter is lost or impaired and the sphincter remains tight, thereby promoting retention of stool. However, fecal incontinence can and does occur. Although there is loss of supraspinal control, the nerve connections between the spinal cord and the colon remain intact; therefore, there is preserved reflex coordination and stool propulsion. The upper motor neuron bowel syndrome is typically associated with constipation and fecal retention at least in part due to external anal sphincter over activity (Steins et al. 1997). Stool evacuation in these individuals occurs in response to stimulation of reflex activity, such as presence of faeces in the rectum, a suppository, enema, or digital rectal stimulation causing rectal distension.

The lower motor neuron bowel, or areflexic bowel, is characterized by the loss of centrally-mediated (spinal cord) peristalsis and loss of reflex activity, resulting in slow stool propulsion and impaired reflex stool evacuation. A segmental colonic peristalsis occurs only due to the activity of the enteric nervous system, which is slower and less efficient than the centrally-mediated peristalsis. The result is increased bowel transit times with the production of drier and round- shaped stool. Lower motor neuron bowel syndrome is commonly associated with constipation and a significant risk of incontinence due to the atonic external anal sphincter and lack of control over the puborecatlis and levator ani muscles; coordinated actions of these striated muscles are important in maintaining continence.

Completeness of injury also has a significant impact on bowel function in individuals with SCI. Those with an incomplete injury may retain some sensation of rectal fullness and some ability to control evacuatory function. However, residual rectal sensation may be abnormal and motor control impaired, resulting in fecal urgency or constipation due to disordered defaecation reflexes. Careful assessment is required.

Table 1: Clinical Presentations in Bowel Functions Following SCI (Singal et al. 2006)

	Upper Motor Neuron lesion	**Lower Motor Neuron lesion**
Level	>T10 vertebral or T12 spinal segment	<T10 vertebral or T12 spinal segment
Time from cecum to anus	Increased	Increased
Motility of left colon	decreased	decreased
External anal sphincter	Spastic paralysis	Flaccid paralysis
Sympathetic output	Absent with lesions > T6 spinal segment	Retained
Symptoms	Constipation Difficulty with evacuation Incontinence	Constipation Difficulty with evacuation Incontinence
Fecal impaction	Proximal colon	Rectal
Autonomic dysreflexia	Common	Rare
Reflex defecation	Present	Not known

To achieve fecal continence and avoid constipation, management of neurogenic bowel dysfunction depends upon regular and frequent pre-emptive interventions to empty the bowel at a planned time and frequency. A strict routine using dietary manipulation, rectal stimulants, oral laxatives and physical interventions such as abdominal massage, digital rectal stimulation and manual evacuation of stool is required to establish control over this profoundly important bodily function. Such multifaceted programs are the most commonly used method of bowel management after SCI (Coggrave et al. 2009) but evidence to support these programs is lacking and much trial and error is involved in development of effective, individualized routines.

Rarely, dangerous complications like sigmoid volvulus, intestinal obstruction, perianal abscess and stercoral perforation may develop (Banwell et al. 1993). In addition, autonomic dysreflexia is a life threatening emergency to which individuals with SCI above the 6th thoracic vertebra are at risk. Bowel dysfunction is the second most common cause of autonomic dysreflexia, a disorder characterized by an abnormal reaction to stimuli below the level of the SCI, resulting in a massive rise in blood pressure that can lead to adverse events including brain haemorrhage and death. Common GI problems reported by up to 41% of individuals with SCI include abdominal pain and bloating, haemorrhoids and rectal prolapse (Correa and Rotter 2000). Prolonged bowel evacuation is also common, particularly in chronically injured individuals (Coggrave et al. 2009; Kirk et al.1997; Lynch et al. 2000); this is as disabling as ineffective management and is associated with anxiety (Glickman & Kamm 1996). The prevalence of chronic GI symptoms increases with time after injury, suggesting that these problems are acquired and potentially preventable (Rajendran et al. 1992).

It is important to emphasize that each person with SCI is unique and that individual bowel programs (maintain continence, ensure completed within a timely manner, safe, etc.) need to be client-specific. The program will reflect not just residual bowel function but also the individual's personal goals, lifestyle and social circumstances. The effectiveness of a bowel program should be reevaluated and modified as needed.

2.1 General Bowel Management Systematic Reviews

Table 2: General Bowel Management Systematic Review

Authors; Country Date included in the review Total Sample Size Score	Methods Databases Level of Evidence	Conclusions
Coggrave et al. 2014; UK Published articles up to June 2012 N=20 AMSTAR: 9	**Methods:** Literature search for randomized and quasi-randomized studies evaluating any type of intervention for management of fecal incontinence and constipation in people with central neurological disease or injury. Only SCI findings are reported. **Databases:** Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE, MEDLINE In-Process, CINAHL, search of relevant journals and conference proceedings.	1. Small trials demonstrated statistically significant improvement in total bowel care time comparing: - intramuscular neostigmine-glycopyrrolate and placebo (mean difference (MD) = 23.3 min) - bisacodyl in polyethylene glycol suppository (43 min) compared with bisacodyl in vegetable oil suppository (74.5 min) and - use of an abdominal electrical stimulation belt vs no stimulation (MD= 29.3 min). 2. One trial showed transanal irrigation significantly improved a range of outcomes compared to conservative management. There was higher patient satisfaction with this method. 3. Three trials of cisapride were withdrawn from the review as the drug is no longer available.
Krassioukov et al. 2010; Canada Published articles from 1950 to July 2009 N= 57 AMSTAR: 5	**Methods:** Literature search for randomized-controlled trials (RCTs), prospective cohort, case–control, pre–post studies, and case reports assessing pharmacological and non-pharmacological interventions for management of neurogenic bowel after SCI. **Databases:** PubMed/MEDLINE, CINAHL, EMBASE, PsycINFO. **Level of Evidence:** PEDRo Scale was used to grade RCTs (0-11). Modified Downs and Black scale was used to grade non RCTs (0 to 28).	1. Multifaceted bowel management programs are the first approach to neurogenic bowel programs and are supported by lower-level evidence (3 pre–post studies, level 4). 2. More than one intervention is usually necessary for individuals to develop an effective bowel routine (e.g. digital rectal stimulation with diet and fluid intake). 3. Evidence is low for non-pharmacological approaches and high for pharmacological interventions. 4. Diet and fluid intake are important components of multifaceted bowel management programs. 5. Transanal irrigation is a promising technique to reduce constipation and fecal incontinence 6. Colostomy is a safe, effective method of managing severe and chronic GI problems, and assist with treating perianal pressure ulcers in persons with SCI.

Discussion

Two relevant systematic reviews were found. Krassioukov et al. (2010) reviewed all research literature published from 1950 to July 2009 related to neurogenic bowel management in individuals with SCI. They reported that although multifaceted bowel management programs are commonly used, only lower levels of evidence support these programs. Coggrave et al. (2014) found 20 randomized or quasi-randomized trials published up to June 2012. There was evidence that the duration of bowel care could be significantly reduced through use of drugs and electrical stimulation, and that transanal irrigation improved a range of outcomes. Both reviews noted that there is a need for more high quality research in the field of bowel management for SCI patients. Future trials should include evaluation of the ‘acceptability of the intervention to patients and the effect on their quality of life’.

3.0 Conservative Bowel Management

Due to loss or impairment of sensation of rectal fullness and voluntary control of anorectal function in upper motor neuron SCI with intact anorectal reflex, bowel evacuation must be stimulated for bowel movements to occur on a regular and predictable basis. This facilitates continence and reduces constipation. As many SCI individuals need assistance with activities of daily living, and in many cases care has to be scheduled, a regular bowel program ensures evacuation occurs when that assistance is available. Prevention of constipation will avoid symptoms such as abdominal pain and bloating and minimize the development of anorectal morbidities associated with neurogenic bowel dysfunction including haemorrhoids, anal fissure, rectal abscess and rectal prolapse.

A conservative bowel program will combine a number of interventions in an individualized routine and may include dietary manipulation to ensure adequate fibre and fluid, digital rectal stimulation, digital removal of stool, abdominal massage, stimulation of the gastrocolic reflex, use of oral or rectal (suppositories, enemas) pharmacological interventions. Such a program will usually be performed on a daily or alternate day basis depending on the needs of the individual. Undertaking physical activity, including standing and passive movements, may also help to reduce constipation. Polypharmacy may also contribute to constipation so wherever possible medications that adversely affect bowel function should be minimized or avoided. Where this is not possible and when appropriate dietary intake is not practicable, oral laxatives may be used to modulate stool consistency and promote stool transit.

The Consortium for Spinal Cord Medicine guidelines (1998) and the Multidisciplinary Association of Spinal Cord Injury Professionals guidelines (MASCIP 2012) recommend that a conservative bowel program should be developed initially in the rehabilitation phase following injury and that a comprehensive evaluation of bowel function and management is undertaken at least annually. The evaluation may include a patient history (including level and completeness of SCI, detailed history of current bowel routine management, stool form, continence and time spent on evacuation, diet and fluid intake, relevant medical conditions and medications, extent of care provision and home adaptations) and a detailed physical examination (including neurological examination to ascertain upper motor neuron vs. lower motor neuron type of neurogenic bowel and a rectal examination).

3.1 Multifaceted Programs

Multifaceted programs include a number of different interventions combined in a bowel routine to promote effective and timely fecal evacuation.

Table 3: Multifaceted Bowel Management Programs

Author Year; Country Score Research Design Total Sample Size	Methods	Outcome
Coggrave & Norton 2010; UK PEDro = 7 RCT N = 68	**Population:** Experimental group: 24M 11F; Median age = 49.5yrs; 17 AIS-A, 5 AIS-B, 4 AIS-C, 9 AIS-D. Control group: 21M 12F; Median age = 47 yrs; 19 AIS-A, 3 AIS-B, 2 AIS-C, 9 AIS-D. **Treatment:** 6-week, 8-stepwise protocol designed by Badiali et al. (2007) 1) simulation of gastro-colic reflex 20 min before starting bowel care followed by: 2) abdominal massage; 3) perianal digitation; 4) anorectal digitation; 5) glycerin suppositories; 6) rectal stimulants; 7) manual evacuation; 8) stimulant oral laxative. The control group maintained	1. Bowel care was consistently longer in the experimental group throughout the study, and significantly longer at week 6. 2. Less invasive interventions (i.e. steps 1-5) did not reduce the need for more invasive interventions (i.e. steps 6-8). 3. Time to first stool was consistently but not significantly longer in the experimental group. 4. Findings supported the need for manual evacuation of stool in neurogenic bowel management

Author Year; Country Score Research Design Total Sample Size	Methods	Outcome
	their usual bowel routine to achieve evacuation. **Outcome Measures:** duration of bowel movement and level of the 8-stepwise protocol reached to attain consistent evacuation.	
Coggrave et al. 2006; UK Pre-post N=17	**Population:** 14M 3F; Age: mean 41.2 yrs, range 19-59yrs; 8 cervical, 8 thoracic, 1 conus medullaris; all subjects had motor compete SCI. **Treatment:** Baseline bowel management routine (2 weeks observation) was compared with bowel management following introduction of the modified progressive protocol (4 weeks of observation) designed by Badiali et al. (1997) with the addition of manual evacuation. **Outcome Measures:** Comparison of the number of bowel management episodes requiring laxative use at baseline and under the progressive protocol; duration of bowel management episodes.	1. For 12 subjects, use of the progressive protocol resulted in an increase in the number of successful bowel management episodes without the use of laxatives. 2. Total number of successful bowel management episodes requiring laxative decreased significantly from 62.8% (baseline observation) to 23.1% (in protocol phase). 3. In 3 subjects, there were fewer successful bowel management episodes with use of the protocol 4. Mean duration of bowel management episodes was less with use of the protocol than during baseline (51.8 vs. 73.5 minutes). 5. There was a significant decrease in proportion of the bowel management episodes requiring manual evacuation in the protocol phase than in the baseline phase (87.6% versus 27%).
Correa & Rotter 2000; Chile Pre-post N=38	**Population:** Age: range 19-71 yrs; 21 subjects with complete injuries (2 with tetraplegia and 19 with paraplegia), 10 with incomplete injuries, 7 with conus medullaris and cauda equina; Duration of injury: range 5 months -16 yrs. **Treatment:** Intestinal program administration with 6-month follow-up. The program involved monthly evaluations of the patient's intestinal function, symptoms and complications. Patients were educated on inadequate practices of evacuation and medications were changed when appropriate. **Outcome Measures:** Difficult Intestinal Evacuation (DIE) scale; colonic transit time; anorectal manometry; recto-colonoscopy; GI symptoms.	1. Subjects felt their DIE scores after their SCI worsened (from 2.6% to 26.3%) compared to before their SCI (based on subjective recall). 2. The most frequent GI symptom was abdominal distention. The incidence of abdominal distention was reduced from 50% to 23.5% after the program. 3. With the intestinal program, the incidence of DIE was reduced from 26.3% to 8.8% and episodes of manual extraction was reduced from 53% to 37%.
Badiali et al. 1997; Italy Pre-post N=10	**Population:** 5M 5F; Age: mean 33yrs, range 20-60yrs; Level of injury: C3 to L4 **Treatment:** Multifaceted intervention including diet, water intake, and evacuation schedule (15g/die fibre, 1500ml/24hr water) **Outcome Measures:** Bowel movement frequency, bowel habit (regular intestinal schedule), total and segmental large-bowel transit time.	1. Bowel frequency was reported to have increased at the end of training. 2. By the end of the study period the total GI transit time was significantly reduced (146+/-45 before vs 93+/-49 h).

Discussion

A combination of interventions, as components of a comprehensive bowel routine, is recommended for the management of neurogenic bowel following SCI. These include dietary manipulation, anorectal stimulation and manual evacuation, timing the performance of the bowel routine to follow food intake (thus taking advantage of gastro-colic and recto-colonic reflexes), and a variety of pharmacological agents, oral and rectal. Unfortunately, only a limited number of studies evaluated the effects of different protocols on bowel function following SCI. From the results of three pre-post studies and one RCT, it is apparent that response to the protocols is highly individualized. However, Badiali et al.'s (1997) multifaceted bowel management program effectively reduced gastrointestinal transit time while Correa and Rotter's (2000) program reduced the incidence of difficult evacuation. Coggrave et al. (2006) modified the bowel management program originally proposed by Badiali et al. (1997) by including an additional step of manual evacuation and found a significant decrease in the number of bowel movement episodes requiring laxatives (from 62.8% to 23.1%). These authors also reported a significant decrease in the mean duration of bowel management episodes with introduction of this protocol (Coggrave et al. 2006). As these three studies incorporated several factors into the bowel management programs including diet, fluid consumption, and routine bowel practice, it is not possible to determine the key factor. Using the same management program in their 2006 pre-post study (Coggrave et al. 2006), Coggrave and Norton (2010) more recently conducted a 6-week RCT in which the management program was compared to the control group's usual bowel care consisting of each subject's usual type, number and order of interventions to achieve evacuation. The authors wanted to examine whether systematic use of less invasive interventions (i.e. the first few steps in the management program: simulation of gastro-colic reflex 20 min before starting bowel care, abdominal massage, perianal digitation, anorectal digitation and glycerin suppositories), could reduce the need for oral laxatives or more invasive interventions such as rectal stimulants and manual evacuation. Findings revealed that bowel care took longer in the experimental group, fecal incontinence was more frequent ($p=0.04$), and the need for oral laxatives and invasive interventions was not reduced ($p=0.4$). The findings in this RCT (Coggrave & Norton 2010) are in contrast with other published findings in which the use of a multifaceted program reduced the level of intervention needed for evacuation and duration of bowel management (Coggrave et al. 2006; Badiali et al. 1997). The samples in the earlier studies, however, were younger and injured for a shorter period of time, and both factors are associated with less frequent use of medicated rectal stimulants, manual evacuation, and oral laxatives (Coggrave et al. 2009).

Conclusion

There is level 1b evidence (from one RCT; N=68) (Coggrave & Norton 2010) that systematic use of less invasive interventions does not reduce the need for oral laxatives or more invasive interventions such as rectal stimulants and manual evacuation.

There is also level 1b evidence (Coggrave & Norton 2010) that use of a multifaceted bowel management program may increase the duration of bowel management. This is in contrast with level 4 evidence (from three pre-post studies; aggregate N=65) (Coggrave et al. 2006; Correa and Rotter 2000; Badiali et al. 1997) that multifaceted bowel management programs may reduce GI transit time, incidences of difficult evacuations, and duration of time required for bowel management.

> There is limited and conflicting evidence in support of multifaceted bowel management programs for managing neurogenic bowel dysfunction.

3.2 Dietary Fibre

It is well known that fibre, in appropriate quantities, is an important part of a healthy diet. There are different types of fibre, each benefiting the body in different ways. Soluble fibre mixes with water in the intestine to form a gel-like substance, which acts as a trap to collect certain body wastes and then move them out of the body. Insoluble fibre absorbs and holds water, producing uniform stool and helping to push gut contents through the digestive system quickly. Insoluble fibre in appropriate amounts and with additional fluid intake can promote bowel regularity and improve constipation.

The Consortium for Spinal Cord Medicine (1998) recommends an initial diet with no less than 15 grams of fibre daily, and the Multidisciplinary Association of Spinal Cord Injury Professionals (MASCIP) (2009) group recommends an average intake of 18 grams, however, they acknowledge that adjustments should be made if problems arise with stool consistency. It is currently not recommended to uniformly place individuals with SCI on high fibre diets due to individual differences and tolerances (Consortium for Spinal Cord Medicine, 1998).

Table 4: Dietary Fibre for Managing Neurogenic Bowel after a Spinal Cord Injury

Author Year; Country Score Research Design Total Sample Size	**Methods**	**Outcome**
Cameron et al. 1996; Australia Case Series N=11	**Population:** Age: range 19-53yrs; Level of injury: C4-T12; 1 subject with incomplete injury and 10 with complete injuries; 7 subjects with tetraplegia and 4 with paraplegia. All participants were in their first rehabilitation program 1-4 months after injury. **Treatment:** In phase 1 (week 1), subjects ate a normal hospital diet and maintained their bowel routine. In phase 2 (week 2-4), fibre intake was increased with the addition of 40g Kellogg's All Bran. **Outcome Measures:** stool weight, total and segmental transit time, bowel evacuation time and dietary intake.	1. Following the addition of bran, dietary fibre intake significantly increased from 25g/d to 31g/d. 2. Mean colonic transit time significantly lengthened from 28.2 hours to 42.2 hours

Discussion

While many individuals with SCI report that adjusting their diet improves bowel function (Coggrave et al. 2006b), there is scant evidence to support this. Cameron et al. (1996) looked at increasing dietary fibre and found that this does not have the same effect in individuals with SCI as has been previously demonstrated in individuals without neurogenic bowel dysfunction. The effect may actually be the opposite of the desired result. Therefore, adding more fibre alone does not improve bowel function; for individuals with low fibre intake and constipation, fibre in the diet may be increased gradually and the effect on bowel function carefully observed. More evidence is required to assess the effectiveness of adding fibre to the diet of individuals with SCI.

Conclusion

There is level 4 evidence (from one case series; N=11) (Cameron et al. 1996) that indicates high fibre diets may lengthen colonic transit time in individuals with SCI.

There is a need for further research to examine the optimal level of dietary fibre intake in patients with SCI.

3.3 Stimulation of Reflexes in the Gastrointestinal Tract

Utilization of the preserved gastrointestinal reflexes can be beneficial in bowel management following SCI. The gastro-colic reflex is stimulated by gastric distention due to eating and can activate bowel motility and promote defecation (Sloots et al. 2003; Ford et al. 1995). Digital stimulation of ano-rectal reflexes has been shown to result in increased rectal contractions and could be useful in bowel evacuation following SCI (Shafik et al. 2000).

Table 5: Reflex stimulation of the Gastrointestinal Tract

Author Year; Country Score Research Design Total Sample Size	**Methods**	**Outcome**
Korsten et al. 2007; USA Pre-post N=6	**Population:** Six male subjects with SCI (4 with paraplegia [3 complete, 1 incomplete]; 2 with tetraplegia [1 complete, 1 incomplete); Age: mean 50.2yrs, range 44-50yrs; Level of injury: C5-T10; AIS A-C; Duration of injury: 10-29yrs. **Treatment:** Digital rectal stimulation to facilitate bowel evacuation. **Outcome Measures:** Colorectal monometry: mean number of peristaltic waves per minute; amplitude of contractions; colonic motility.	1. Compared with no digital rectal stimulation (0 waves/min), the mean number of peristaltic waves/min increased during digital rectal stimulation (1.9±0.5/min) and immediately after digital rectal stimulation (1.5±0.3/min) (mean ± SEM). 2. Average amplitude of the peristaltic contractions was 43.4±2.2 mmHg (range 0.7-250 mmHg). 3. Peristaltic contractions in the left colon were accompanied by increased motility of the left colon and improvement in evacuation of barium as documented by fluoroscopy.

Discussion

A single pre-post study demonstrates that digital rectal stimulation increases peristaltic waves in the left colon, thus increasing motility in this segment and aiding evacuation of stool in those with reflex bowel dysfunction (Korsten et al. 2007). Stimulation of ano-rectal reflexes in individuals with SCI above the conus can therefore be incorporated into bowel routines; pharmacological rectal stimulants can be used to trigger evacuation at a chosen time in combination with digital rectal stimulation. There is conflicting evidence regarding the strength of the gastrocolic reflex after SCI (Glick et al. 1984; Aaronson 1985; Menardo et al. 1987) but this noninvasive intervention may be helpful in individuals with any level of injury and is worthy of evaluation when developing an individual program.

Conclusion

There is level 4 evidence (from one pre-post study; N=6) (Korsten et al. 2007) that digital rectal stimulation increases motility in the left colon.

Digital rectal stimulation increases motility in the left colon in individuals with reflex neurogenic bowel dysfunction after SCI.

3.4 Manual Evacuation of Faeces

Manual evacuation of faeces involves the use of a single gloved and lubricated finger to remove faeces from the rectum. It is used by individuals with both hyperreflexic and areflexic bowel dysfunction. Coggrave et al. (2009) (n=1334) reported that manual evacuation of faeces for people with SCI was found to be the most commonly used intervention, carried out by 56% of respondents. A systematic review (Solomons & Woodward 2013) found that digital stimulation and digital removal of faeces were associated with the lowest rates of unplanned bowel evacuations and less time spent on bowel care (Haas et al. 2005) and concluded that digital removal of faeces is a necessary component of bowel care for many individuals with SCI.

Table 6: Manual Evacuation of Faeces Systematic Review

Authors; Country Date included in the review Total Sample Size Types of Articles Score	Methods Databases Level of Evidence	Conclusions
Solomons & Woodward 2013; Britain Systematically reviewed articles from electronic databases no date limits applied N=7 **Level of evidence:** Methodological quality not assessed **Type of study:** 1 RCT 4 case-controls 1 cross-sectional 1 case-control AMSTAR: 2	**Method:** Systematic literature review of the quality of evidence available on fecal manual evacuation for individuals with SCI. **Databases:** CINAHL, British Nursing index, EMBASE, Medline	1. There have been 2 multicentre studies of bowel management programs involving digital removal of faeces. One descriptive longitudinal study of outpatients from 2 centres determined that digital removal of faeces and digital stimulation had the highest self-reporting of constipation. The other study included data collected from multiple SCI centres in 4 German-speaking countries and found that digital removal of faeces and digital stimulation were associated with the lowest rates of unplanned bowel evacuations and led to less time spent on bowel care. 2. Bowel protocols should not be carried out rigidly but rather should be used in guided experimentation to assist the SCI patient to find a bowel management program that works for them. 3. Digital rectal removal of faeces remains a necessary intervention for many patients. More research and training are needed on this and other neurogenic bowel management. 4. The low status of bowel care in nursing and wider society needs to be challenged so that people with SCI can benefit from high quality bowel care and associated improvements in quality of life.

Table 7: Studies on Manual Evacuation of Faeces

Author Year; Country Score Research Design Total Sample Size	Methods	Outcome
Badiali et al. 1997; Italy Pre-post N=10	**Population:** 5M 5F; Age: mean 33yrs, range 20-60yrs; Level of injury: C3 to L4. DOI 2-23 yrs. **Treatment:** Multifaceted intervention including diet, water intake, and evacuation schedule (15g/die fibre, 1500ml/24hr water) Progressive protocol with oral laxatives used as a last resort. Protocol did not include manual evacuation, but 4/10 participants used manual evacuation as a baseline. **Outcome Measures:** Bowel movement frequency, bowel habit (regular intestinal schedule), total and segmental large-bowel transit time.	1. Bowel frequency was reported to have increased at the end of training (baseline: 2.9 +/- 2 vs protocol: 4.1+/-3 events/wk). 2. By the end of the study period the total GI transit time was significantly reduced (146+/-45 before vs 93+/-49 h).

Author Year; Country Score Research Design Total Sample Size	Methods	Outcome
Coggrave et al. 2006; UK Pre-post N=17	**Population:** 14M 3F; Age: mean 41.2 yrs, range 19-59yrs; 8 subjects with cervical injuries, 8 with thoracic injuries, 1 with conus medullaris; all subjects had motor compete SCI. **Treatment:** Baseline bowel management routine (2 weeks observation) was compared with bowel management following introduction of the modified progressive protocol (4 weeks of observation) designed by Badiali et al. (1997) with the addition of manual evacuation. **Outcome Measures:** Comparison of the number of bowel management episodes requiring laxative use at baseline and under the progressive protocol; duration of bowel management episodes.	1. For 12 subjects, use of the progressive protocol resulted in an increase in the number of successful bowel management episodes without the use of laxatives. 2. Total number of successful bowel management episodes requiring laxative significantly decreased from 62.8% (baseline observation) to 23.1% (in protocol phase). 3. In 3 subjects, there were fewer successful bowel management episodes with use of the protocol 4. Mean duration of bowel management episodes was less with use of the protocol than during baseline (51.8 vs. 73.5 minutes). 5. There was a significant decrease in proportion of the bowel management episodes requiring manual evacuation in the protocol phase than in the baseline phase (87.6% versus 27%).
Coggrave et al. 2009; UK Pre-post N=1334	**Population:** 1334 SCI outpatients aged 19-91 yrs. **Treatment:** Postal survey **Outcome measures:** method of evacuation; number of interventions used before finding a successful protocol; assistance with bowel care.	1. 56% of respondents used digital rectal evacuation; 36% stimulant laxatives, 15% osmotic, 6% bulk formers, 3% stool softeners. 2. Median number of interventions used by an individual was 3. 3. More than 1/3 of respondents needed assistance with bowel care. 4. Digital evacuation was associated with better outcomes in independent individuals with thoracic lesions.
Coggrave & Norton 2010; UK PEDro = 7 RCT N = 68	**Population:** Experimental group: 24M 11F; Median age = 49.5yrs; 17 AIS-A, 5 AIS-B, 4 AIS-C, 9 AIS-D. Control group: 21M 12F; Median age = 47 yrs; 19 AIS-A, 3 AIS-B, 2 AIS-C, 9 AIS-D. **Treatment:** 6-week, 8-stepwise protocol designed by Badiali et al. (2007) 1) simulation of gastro-colic reflex 20 min before starting bowel care followed by: 2) abdominal massage; 3) perianal digitation; 4) anorectal digitation; 5) glycerin suppositories; 6) rectal stimulants; 7) manual evacuation; 8) stimulant oral laxative. The control group maintained their usual bowel routine to achieve evacuation. **Outcome Measures:** duration of bowel movement and level of the 8-stepwise protocol reached to attain consistent evacuation.	1. Bowel care was consistently longer in the experimental group throughout the study, and significantly longer at week 6 2. Less invasive interventions (i.e. steps 1-5) did not reduce the need for more invasive interventions (i.e. steps 6-8). 3. Time to first stool was consistently but not significantly longer in the experimental group 4. Findings supported the need for manual evacuation of stool in neurogenic bowel management
Correa & Rotter 2000; Chile Pre-post	**Population:** Age: range 19-71 yrs; 21 subjects with complete injuries (2 with tetraplegia and 19 with paraplegia), 10 with incomplete injuries, 7 with conus medullaris and cauda equina;	1. Subjects felt their DIE scores after their SCI worsened (from 2.6% to 26.3%) compared to before their SCI (based on subjective recall).

Author Year; Country Score Research Design Total Sample Size	Methods	Outcome
N=38	Duration of injury: range 5 months -16 yrs. **Treatment:** Intestinal program administration with 6-month follow-up. The program involved monthly evaluations of the patient's intestinal function, symptoms and complications. Patients were educated on inadequate practices of evacuation and medications were changed when appropriate. Manual evacuation was discouraged as high-risk. **Outcome Measures:** Difficult Intestinal Evacuation (DIE) scale; colonic transit time; anorectal manometry; recto-colonoscopy; GI symptoms.	2. The most frequent GI symptom was abdominal distention. The incidence of abdominal distention was reduced from 50% to 23.5% after the program. 3. With the intestinal program, the incidence of DIE was reduced from 26.3% to 8.8% and episodes of manual extraction was reduced from 53% to 37%. 4. An objective to eliminate use of manual evacuation, stimulant laxatives and/or enemas was successful in that 19 patients were using manual evacuation daily pre-trial while only 8 did post-trial.
Haas et al. 2005; Switzerland Cross-sectional N=837	**Population:** 837 SCI patients (642M, 186F) from 29 rehabilitation facilities in Austria, Germany, the Netherlands and Switzerland. Injury level: 42% cervical, 45.3% thoracic, 12.7% lumbar. **Treatment:** questionnaire **Outcome measures:** method of evacuation, rate of incontinence, rate of bowel symptoms	1. Oral laxatives were significantly associated with increased unplanned bowel evacuations and longer episodes of bowel care. 2. Fewer unplanned evacuations were significantly associated with manual removal and/or digital rectal stimulation. 3. Manual evacuation associated significantly with shorter duration of bowel evacuation (<60 min).
Menter et al. 1997; UK Retrospective longitudinal N=221	**Population:** 221 SCI patients; 29% tetraplegia (ASIA A/B/C), 49% had paraplegia (ASIA A/B/C) and the remaining 21% were classified as having incomplete, ASIA D paraplegia or tetraplegia. **Treatment:** questionnaire, physical examination, physiological measurements. **Outcome measures:** medical records, bowel management techniques.	1. 80% of individuals with paraplegia, 68% with tetraplegia and 23% with incomplete SCI used manual evacuation. 2. Those who used manual evacuation or digital stimulation self-reported the highest rate of constipation at 44.4% and GI pain at 41.5%, but a lower rate of incontinence at 26.1%. 3. GP diagnosed just 14.1% constipation for patients who used manual evacuation or digital stimulation, in contrast to the self-reported %.

Discussion

Solomons & Woodward (2013) reviewed 7 articles which used manual evacuation as part of a bowel management protocol. They found that manual evacuation was very commonly used in individuals with SCI (Menter et al. 1997; Coggrave et al. 2006; Coggrave et al. 2009), and was effective in reducing the number of unplanned bowel evacuations (Haas et al. 2005), but had a high self-reported rate of constipation (Menter et al. 1997). Conversely, Haas et al. (2005) reported a decrease in bowel evacuation time with manual evacuation. It is worth noting that the GP diagnosis of constipation in Menter et al. (1997) was significantly lower than the self-reported rate of constipation.

Conclusion

Manual evacuation is a key method in conservative bowel management practice and is commonly and widely employed. It reduces number of unplanned bowel evacuations. There is conflicting evidence on the effect of manual evacuation on duration of bowel evacuation.

Digital evacuation of stool is a very common intervention for bowel management after SCI, reducing duration of bowel management and fecal incontinence.

3.5 Abdominal Massage

Table 8: Abdominal Massage

Author Year; Country Score Research Design Total Sample Size	**Methods**	**Outcome**
Hu et al. 2013; China Pre-post N=20	**Population:** Thoracic SCI (13M, 7F); Mean (SD) age: 39.70 (5.25) yrs. **Treatment:** Abominal massage was applied to the surface of the abdomen along the small intestine, the ascending, transverse, descending and sigmoid colon, for 60 sessions during the bowel routine (5 times/wk for 12 wks). **Outcome Measures:** Bowel time, dosage of glycerine enema.	1. A statistically significant improvement was found in the mean(SD) time of bowel movement (decreased from 94.0 (16.4) min to 60.5 (10.5) minutes) and dosage of glycerine enema (decreased from 68.15 (8.9) mL to 31.5 (11.8) mL) after abdominal massage treatment for 3 months.
Ayas et al. 2006; Turkey Pre-post N=24	**Population:** Age: mean 39.8yrs, range 33.1-46.6yrs; Level of injury: C4-L3, 10 subjects with supraconal lesions, 14 with caudal/conal lesions; 15 with complete SCI and 9 with incomplete SCI; FIM score: mean 76.3, range 68.9-83.7; Duration of injury: mean 136.5 days, range 70.1-203 **Treatment:** Addition of abdominal massage beginning at the cecum and extending along the length of the colon to the rectum (phase II) to a standard bowel program (phase I) **Outcome Measures:** Colonic transit times, frequency of defecation	1. Mean (SD) frequency of defecation significantly increased from 3.79(2.15) (range 2.75-4.55) to 4.61(2.17) (range 3.67-5.54) per week. 2. Mean (SD) total colonic transit time significantly decreased from 90.60(32.67) (range 75.87-110.47) hours to 72(34.10) (range 58.49-94.40) hours with abdominal massage.

Discussion

Ayas and colleagues (2006) reported on individuals with SCI who received at least 15 minutes of abdominal massage beginning at the cecum and extending along the length of the colon to the rectum during their regular bowel routine. Differences were found in the frequency of defecation and mean colonic transit time between phase I, when subjects participated in a standard bowel program in which they received a standard diet containing 15-20 g of fiber/day and underwent daily digital stimulation, and phase II, when the subjects continued to receive this standard care and had the addition of abdominal massage when attempting bowel evacuation. However, these differences were statistically insignificant, possibly due to a small and heterogeneous sample. In the study by Hu et al. (2013), manual therapy was applied to the intestine and along the colon. A statistically significant improvement was seen in the meantime of bowel movement as well as dosage of glycerine enema needed. The sample in this study was also very small but was homogenous. Further suitably powered studies are required in the SCI population to determine the effectiveness of abdominal massage as an intervention for neurogenic bowel dysfunction.

Conclusion

There is level 4 evidence (from one pre-post study; N=24) (Ayas et al. 2006) that abdominal massage is ineffective for treating the neurogenic bowel.

There is conflicting level 4 evidence (from one pre-post study; N=20) (Hu et al. 2013) that abdominal massage is effective in reducing bowel movement time as well as dosage of glycerine enemas.

There is contrasting evidence on the effectiveness of abdominal massage in treating neurogenic bowel dysfunction. Further research is needed.

3.6 Electrical and Magnetic Stimulation

After upper motor neuron SCI, bowel reflex centres within the sacral spinal cord may be released from descending inhibition, and may be influenced by somatic input (Frost et al. 1993). A number of studies have shown that electrical or magnetic stimulation of the somatic nervous system can bring about an alteration in visceral function in humans. For example, Riedy et al. (2000) showed that short periods of electrical stimulation with perianal electrodes resulted in an increase in anal pressures.

The sacral anterior root stimulator (SARS) employs electrodes implanted onto the second, third and fourth sacral anterior nerve roots to deliver short bursts of high voltage stimulation several times daily resulting in increased colonic activity, reduced constipation and sometimes defaecation during the stimulation.

A significant number of electrical or magnetic stimulation methods have been proposed and tested for their ability to improve bowel function in individuals with upper motor neuron SCI. These techniques are varied, from the relatively inexpensive and non-invasive abdominal muscle stimulation belt (Korsten et al. 2004) and percutaneous peripheral nerve stimulation (Mentes et al 2007), to more complex and invasive techniques including implantation of epineural electrodes (Davis et al. 2001) and epidural or anterior sacral root electrodes (Kochourbos et al. 2000; Chia et al. 1996; Binnie et al. 1991; MacDonagh et al. 1990) for functional electrical stimulation. Magnetic stimulation techniques have also been also used; a magnetic field is generated in order to induce an electric field, which then generates sufficient current to stimulate the peripheral nerves (Lin et al. 2002).

Sun et al. (1995) investigated the role of spinal reflexes in anorectal function. Their subjects (C6-T12 traumatic SCI) underwent anorectal manometry and electromyography before and after having a sacral posterior rhizotomy performed by the same neurosurgeon. They found that all subjects lost conscious control of the external anal sphincter as well as responses to intra-abdominal pressure and rectal distention (EAS electromyographic activity, increase in anal pressure), demonstrating the significant role of spinal reflexes.

A review paper on low amplitude chronic electrical stimulation of the sacral plexus (Kenefick and Christiansen 2004), has been reported to reduce fecal incontinence and constipation in selected patients with incomplete SCI. Magnetic stimulation may produce similar results and is noninvasive. Morren et al. (2001) studied the effects of magnetic sacral root stimulation on anorectal pressure and volume in individuals with fecal incontinence and in patients with SCI. They found that magnetic sacral root stimulation produces an increase in anal and rectal pressure and a decrease in rectal volume in healthy subjects and patients with fecal incontinence or a spinal cord injury.

Table 9: Systematic Review on Electrical and Magnetic Stimulation

Authors; Country Date included in the review Total Sample Size Types of Articles Score	Methods Databases Level of Evidence	Conclusions
Worsoe et al. 2013; Denmark Systematically reviewed articles from databases listed to the right (dates searched not listed) Number of studies not listed Level of evidence: methodological quality not assessed Type of study: No RCTs, all lower-level studies AMSTAR: 2	**Method:** Systematic literature search of neurogenic bowel disorder in patients with SCI treated by sacral anterior root stimulation (SARS), sacral nerve stimulation (SNS), peripheral nerve stimulation, magnetic stimulation and nerve rerouting. **Databases:** PubMed, Embase, Scopus, Cochrane Library	1. SARS improves bowel function in some patients with complete SCI. 2. Nerve re-routing is claimed to facilitate defecation through mechanical stimulation of dermatomes in patients with complete or incomplete SCI or myelomeningocele. 3. SNS can reduce NBD in selected patients with a variety of incomplete neurologic lesions. 4. Peripheral stimulation using electrical stimulation or magnetic stimulation may present non-invasive alternatives.

Table 10a: Functional Electrical or Magnetic Stimulation for of Skeletal Muscles

Author Year; Country Score Research Design Total Sample Size	Methods	Outcome
Korsten et al. 2004; USA PEDro=6 RCT N=8	**Population**: 8 male subjects (6 tetraplegia; 2 paraplegia); age mean(SD): 48(14)yrs; duration of injury mean(SD):13(8)yrs. **Treatment:** An abdominal belt with embedded electrodes was wrapped around at the umbilicus level and was used in conjunction with the subject's regular bowel care but activation of the device was randomized. Subjects used the belt for six bowel care sessions over 2 weeks (the belt was activated for three sessions and deactivated for three sessions). **Outcome Measures:** Time to first stool, time for total bowel care.	1. Time to first stool and time for total bowel care were significantly shortened in the 6 subjects with tetraplegia, but not in the 2 subjects with paraplegia.
Worsoe et al. 2012; Denmark Cross-sectional N=7 Level 4	**Population:** Subjects with supraconal SCI (6M, 1F); Age: median (range) age: 50 (39-67); median (range) DOI: 19 (12-33). **Treatment:** Dorsal genital nerve (DGN) stimulation using an amplitude of twice the genito-anal reflex threshold. A pressure controlled phasic rectal distension protocol was repeated 4 times with subjects randomized to stimulation	1. Median rectal CSA was smaller with than without stimulation in all patients at 20cmH_2O distension pressure (median decrease of 9%) and in 6/7 patients at 30cmH_2O distension pressure (median decrease 4%) above resting rectal pressure. 2. Rectal pressure-CSA relation was significantly reduced during stimulation at 20cmH_2O and 30cmH_2O distension.

Author Year; Country Score Research Design Total Sample Size	Methods	Outcome
	during 1st and 3rd distension series or 2nd and 4th distension series. **Outcome Measures:** Rectal cross sectional area (CSA) and rectal pressure	
Tsai et al. 2009; Taiwan Pre-Post N = 22	**Population:** 22 chronic SCI subjects with intractable neurogenic bowel dysfunction (19M, 3F), mean age 46.7 yrs, range 22–65yrs); divided into group 1 (supraconal lesion, N=15) and group 2 (incomplete conal/caudal lesion, N=7) **Treatment:** subject underwent a 3-week stimulation period, consisting of 20-min stimulation sessions twice a day. Each session contained 10 min of thoracic nerve stimulation with the centre of the coil placed at the T9 spinal process, and another 10 min of lumbosacral nerve stimulation with the coil at the L3 spinal process. Subjects underwent stimulation from a sitting position. The stimulation intensities were set at 50% on the first day, 60% on the second day, and then stabilized at 70% for the remaining days. The stimulation frequency, burst length, and interburst intervals were fixed at 20 Hz, 2 sec, and 28 sec, respectively. **Outcome Measures:** Colonic transit times; Knowles-Eccersley-Scott Symptom Questionnaire (KESS, evaluates frequency of bowel movement using existing therapy, difficulty of evacuation, laxative use, and time taken for bowel evacuation)	1. Mean colonic transit times decreased from 62.6 hrs to 50.4 hrs 2. Frequency of laxative use, unsuccessful evacuation attempts, feeling of incomplete defecation, difficulty with evacuation, and time taken to evacuate significantly decreased 3. Mean scores on the KESS significantly decreased from 24.5 to 19.2 points, indicating a significant overall improvement in bowel symptoms.
Hascakova-Bartova et al. 2008; Belgium Prospective Controlled Trial N = 10	**Population:** 7 subjects in the electrical stimulation group (ESG) with level of injury ≥ T10 and complete paralysis of abdominal muscles (6M 1F; mean (SD) age: 42(19) yrs). 3 additional subjects (all male, ages 25, 43, 63) were in the placebo group (PG). **Treatment:** Surface abdominal neuromuscular electrical stimulation. administered 25 min/day, 5 days/wk, for 8 wks **Outcome Measures:** colonic transit measured by radiopaque markers	1. Accelerated colonic transit (ascending, transverse and descending colon) in all subjects who received treatment. The ESG group had a significant decrease in % of number of markers in the ascending, transverse and descending colon after the NMES treatment (8.86 +/- 8.65% markers before NMES vs. 4.57 +/- 5.99% after NMES). 2. No significant changes in the colonic transit for PG (% number of markers in the A+T+D colon: before NMES = 9.17 +/- 5.91 vs. 9.17 +/- 5.04).
Mentes et al. 2007 Turkey Pre-post N=2	**Population:** A 51-year-old woman who had undergone discectomy for lumbar disc herniation 3 years ago and a 31-year-old man with a 10-year history of lumbar cavernous haemangioma. **Treatment:** Posterior tibial nerve stimulation was performed for 30 min, every other day for 4 weeks, and was	1. Both patients showed improvements in Wexner fecal incontinence score, fecal incontinence quality of life scales, clinical parameters and physiological measurements. Significance of improvements not reported in this study.

Author Year; Country Score Research Design Total Sample Size	Methods	Outcome
	then repeated every 2 months for 3 times. **Outcome Measures:** Rectal sensory threshold, Wexner fecal incontinence score, fecal incontinence severity index, fecal incontinence quality of life scales, resting pressure, and maximum squeeze pressure measurements.	
Lin et al. 2002; USA Pre-post N=9	**Population:** 4 subjects with SCI between C3-C7, AIS class: 3 B,1 D; 5 controls, mean (SD) age: 42(5.8) yrs **Treatment:** Each subject participated in a 3-day protocol; day 1: baseline gastric emptying study, day 2: no change in the eating pattern and no intervention,day 3: subjects received functional magnetic stimulation (FMS) while undergoing a second gastric emptying study. **Outcome Measure:** Rate of gastric emptying and time to reach gastric emptying half time ($GEt_{1/2}$)	1. Gastric emptying time post-stimulation was significantly shorter than the baseline for both AB and SCI groups. Mean (SE) $GE_{t1/2}$ for the groups were: AB: baseline= 36(2.9); post-stim=33(3.1) SCI: baseline=84(11.1); post-stim=59(12.7) 2. There was significantly more gastric emptying at 30, 60, 90 and 120 min after FMS than at baseline. For the SCI group, % of gastric emptying at 30, 60, 90 and 120 min were: - baseline: 6(2.9); 16(7.6); 38(5.2); 55(6.7) - post-stim: 26(8); 49(10.2); 61(9); 69(8.6)
Lin et al. 2001; USA Pre-post N=15	**Population:** 13 SCI, 2 able-bodied controls; Level of injury: C3-L1; Duration of injury 11-35 yrs (protocol 2 only); AIS classes: 7 A, 3 B, 1 C. **Treatment**: FMS was delivered via a magnetic coil placed on the trans-abdominal (suprapubic region while subject lay supine) and lumbosacral (L3-L4 along midline) regions. Protocol 1: measured the immediate effects of FMS on rectal pressure Protocol 2: measured the effects of FMS on total and segmental colonic transit times after a 5-week stimulation period (20 min sessions twice a day). Outcomes were collected before and after the 5-wk stimulation program. **Outcome Measures:** rectal pressure, total and segmental colonic transit times	1. Rectal pressures increased with sacrolumbar stimulation, and with transabdominal stimulation. 2. After protocol 2, the mean (SD) colonic transit times decreased from 105.2(6.66) to 89.4(6.94) hours.

Table 10b: Implanted Electrical Stimulation Systems

Author Year; Country Score Research Design Total Sample Size	Methods	Outcome
Lombardi et al. 2011; Italy Retrospective N= 75	**Population:** 75 males with incomplete SCI who received permanent SNM implantation; Age:18-75yrs; year post injury>6 months; suffering from neurogenic bowel symptoms (NBS), neurogenic lower urinary tract symptoms, and/or neurogenic erectile dysfunction refractory to conservative management **Treatment:** Sacral neuromodulation implantation (Medtronic, Inc) Stage 1- electrode inserted percutaneously in third sacral foramina. Stage 2- Permanent implantable pulse generator implanted in patient's buttock only if main symptoms improved by at least 50% during phase 1. Follow-ups scheduled at 1, 3, 6 months post implantation, and subsequently every 6 months **Outcome Measures:** SF-36 health survey questionnaire; number of fecal incontinence episodes per week; number of evacuations per week and Wexner score (severity of fecal incontinence)	1. Mean follow-up period from SNM permanent implantation to final visit was 53 months. 2. Patients presenting with NBS improved all parameters by at least 50% compared with baseline for mean (SD) number of occurrence of fecal incontinence (4.33 (1.66) vs 1.25 (1.17)); days with pads (4.5 (1.51) vs 1.33 (1.16)) and Wexner scores (13.66 (1.50) vs 5.83 (0.98)) per week at baseline vs final visit. 3. A significant improvement (20%) in SF-36 scores for all patients compared with baseline. 4. 11 adverse reactions were reported (5 individuals required change in stimulation sensation, 2 experienced loss of efficacy, 1 reported pain per leg spasticity, 2 reported pain at implanted pulse generator site, 1 reported adverse change in bowel function.
Sievert et al. 2010; Germany Case-Control N SCI treated with SNM= 10	**Population:** 16 males with complete traumatic SCI (>T12, AIS A); 10 in treatment group, 6 controls; mean age 31 (range 19-47) **Treatment:** Implanted with tined lead electrode/sacral nerve modulator (SNM) at third sacral foramen. **Controls:** Prescribed oral antimuscarinics. **Outcome Measures:** Subjects provided bladder, bowel and erectile function diaries and answered questionnaires including <u>laxative use</u>	1. SNM group reported they felt there was sufficient SMN colon movement without oral laxatives 2. SNM group has improved bowel movement control (incontinence events decreased) 3. All SNM subjects reported significantly better quality of life than the controls. The specific SCI questionnaire used was not mentioned and no scores were given. 4. No intra- or post-operative complications were reported for the implant participants.
Lombardi et al. 2009; Italy Case-series N = 23	**Population:** 15M 8F; 2 cervical, 9 thoracic, 13 lumbar; mean (SD) age = 36(9) years; 12 subjects had constipation (C), 11 had fecal incontinence (FI). **Treatment**: sacral neuromodulation - unilateral implantation in the foramen sacral S3 root **Outcome Measures:** Wexner questionnaire, SF-36, number of fecal evacuations per week, time per defecation.	1. Mean time from neurological diagnosis to SNM therapy was 41 months (range 18-96). Mean follow-up time from SNM implantation to final visit was 44.3 months (range 18-96). 2. Both the constipation and fecal incontinence groups experienced significant improvements in the: -Wexner score: *C group*: pre-SNM=19.91, post-SNM final visit=6.82 *FI group:* pre-SNM=13.09, post-SMN final visit=4.91 -had increased evacuations per week: *C group*: pre-SNM=1.65, post-SNM final visit=4.98

Author Year; Country Score Research Design Total Sample Size	Methods	Outcome
		- had decreased number of fecal incontinence per week *FI group:* pre-SNM=4.55, post-SMN final visit=1.32 - reduced time per defecation: *C group:* pre-SNM=45.85, post-SNM final visit=11.67 min. - had a decreased number of pads used/die *fecal incontinence:* pre-SNM=2.36, post-SMN final visit=0.95 3. Both groups had a significant improvement in the mental and general health subscales of the SF-36. 4. A total of 1038 months yielded 12 adverse events in 5 patients: 4 related to pain at generator site, 3 to spasticity pain in lower limbs, 1 to excessive tingling in vaginal area, and 4 for battery changes.
Valles et al. 2009; Spain Pre-post N = 18	**Population:** 9M 9 F; 4 cervical, 13 thoracic, 1 lumbar; AIS: 14 A, 1 B, 3 C; mean age 39 (range 18-63)yrs, **Treatment:** Sacral anterior root stimulator, follow up from 12-21 months post implantation **Outcome Measures:** Use of laxatives, number of bowel evacuation methods used, frequency of and time dedicated to bowel movements, prevalence of constipation, Wexner questionnaire	1. After implantation, fewer patients took laxatives (10 vs. 13) and patients used significantly less methods to evacuate bowel (1.5 vs. 2.1) 2. The frequency of bowel movements significantly increased (10 vs. 6 subjects had bowel movements every day), and time dedicated decreased (11 vs. 9 subjects dedicated <30min) but was not significant. 3. Prevalence of constipation significantly decreased (7 vs. 11); episodes of fecal incontinence increased (18 vs. 16) and the mean Wexner score decreased (4.6 vs. 5.2) but these results were not significant.
Gstaltner et al. 2008; Austria Pre-post N = 11	**Population:** Cauda equine syndrome with flaccid paresis of the anal sphincter muscle and fecal incontinence **Treatment:** Subjects underwent percutaneous nerve evaluation (PNE); following this analysis, a period of external temporary sacral nerve stimulation was performed in the both sides of the S2 or S3, and if the patient showed improvements in outcome measures, a permanent stimulator was implanted (N=5) **Outcome Measures:** Wexner questionnaire, subjects' subjective perceptions of quality of life determined through interview.	1. Improved fecal continence in all 5 subjects (median score of Wexner score decreased from pre-SNS (15 (9-19)) to post-SNS (5(2-9)). 2. Reported perianal sensitivity and deliberate retention of faeces improved in all 5 subjects. 3. Reported improved quality of life in all 5 subjects. 4. One complication was reported - one patient had minimal leakage of cerebrospinal fluid following the PNE, after removal of the needle, no further symptoms were reported.
Holzer et al. 2007; Austria Pre-post N = 36	**Population:** 17 subjects with SCI from spinal cord surgery, 11 from spinal cord trauma, 4 from meningomyelocele; 14M 22F; median age 49 (range 10-79) yrs.	1. Median number of incontinence episodes decreased from 7 (range 4-15) to 2 (range 0-5) in 21 days 2. There were statistically significant improvements in maximum resting and

Author Year; Country Score Research Design Total Sample Size	Methods	Outcome
	Treatment: Sacral nerve stimulation in the sacral foramina S2-S4; follow up after 12 and 24 months for those who underwent permanent implantation after initial evaluation (N=29) **Outcome Measures:** Number of incontinence episodes, maximum resting and squeeze anal canal pressure, American Society of Colorectal Surgeons (ASCRS) Quality of Life questionnaire	squeeze anal pressure after 12 and 24 months. 3. There was significant improvement in the ASCRS Quality of Life questionnaire for subjects who underwent permanent implantation
Jarrett et al. 2005; USA Pre-post N = 12	**Population:** 6 subjects with SCI from disc prolapse, 4 from trauma, and 1 from spinal stenosis; 4M 9F; median age 58yrs (range 39-73). Exclusion criteria: paraplegia. **Treatment:** Temporary sacral nerve stimulation, permanent implant if subject demonstrated positive results, median follow up is 12 months (range 6-24) **Outcome Measures:** Frequency of incontinence; resting and squeeze anal canal pressure ASCRS QoL questionnaire; SF-36 quality of life questionnaire	1. 12 subjects demonstrated positive results and underwent permanent implantation 2. Mean (SD) frequency of incontinence decreased from 9.33 (7.64) episodes per week at baseline to 2.39 (3.69) at last follow up 3. ASCRS QoL coping score significantly improved; the SF-36 QoL scores did not change 4. Neither resting nor squeeze anal canal pressure changed significantly compared to baseline
Johnston et al. 2005; USA Pre-post N=3 (2 had neurogenic bowel outcome measures, results presented for 1)	**Population:** Age: 17-21yrs; all with motor-complete thoracic SCI (T3-T8) of 1-1.5 years duration. **Treatment:** All subjects received implantation of epineural electrodes for skeletal muscle stimulation for upright mobility. 2 subjects also received additional extradural electrodes (S2,3,4) for bowel and bladder management. Stimulation was conducted via 22 channel implanted Praxis FES system. **Outcome Measures:** Rectum and anal sphincter local pressures, patient self-report diary wherein he described the quantity of stool passed during each daily session, the time spent, and a numerical ‘satisfaction’ rating from 1 (least satisfied) to 10 (most satisfied)	1. Low-frequency electrical stimulation (20 Hz, 350 µs, 8mA) at S3 increased anal sphincter and rectal pressure 2. Over a 2-month period, daily use of electrical stimulation appeared to provide a significant improvement in bowel management, causing an increased frequency of defecation, a decrease in time required for bowel evacuation (from 52 min to 23 min), and improved satisfaction over non-stimulation evacuation methods. 2 stimulation strategies were used by the patients: 1) low-freq stim. for 30s on, 30s off for 5-10 min; 2) 5-10 min of low-freq stim followed by 5 min of low/high freq combination stim.
Kachourbos & Creasey 2000; USA Pre-post N= 16	**Population:** Adults with SCI (demographics not reported) and a history of bowel complications **Treatment:** Implantation of sacral roots electrodes (S1-S3) with rhizotomy at the conus medularis. Stimulation was delivered via use of VOCARE Bladder and Bowel Control System (Finetech-Brindley stimulator). **Outcome Measures:** Bowel program times; occurrence of autonomic dysreflexia due to bowel movement; quality of life regarding dependence,	1. Bowel program times were reduced from a mean of 5.4 hours per week pre-operatively to 2.0 hours per week post-operatively 2. Autonomic dysreflexia due to bowel movements was eliminated 3. Users reported a greater sense of independence, increased socialization, greater control over their lives, improved self-image, decreased feelings of depression, improved interpersonal relationships and an

Author Year; Country Score Research Design Total Sample Size	Methods	Outcome
	socialization, sense of control, and overall quality of life	overall improvement in quality of life
Chia et al. 1996; Singapore Pre-post N=8	**Population:** Level of injury: 4 C4-C6, 4 T3-T11; 6M: 2F; Age: mean 40, range 20-53yrs. All subjects suffered from severe constipation (≤2 bowel movements/week and/or straining at stool for >25% of the time) **Treatment:** Anterior sacral roots electrodes (S2,3,4) implanted for electrical stimulation. **Outcome Measures:** Bowel frequency, laxative use, suppository use, need for digital evacuation, anorectal monometry	1. 6/8 patients had improvement in bowel function: 4/6 were able to evacuate spontaneously after stimulation, 1 described digital evacuation as "easier," 1 used an occasional suppository without the need to digitally evacuate. 2. Six subjects with improved bowel routine also showed increased rectoanal pressure immediately after stimulation.
Binnie et al. 1991; UK Prospective Controlled Trial N=27	**Population**: 3 groups: 1) a control group of 10 healthy volunteers (8M 2F; mean age: 29.1) 2) 10 SCI subjects without the Brindley implant (9M 1F; C4-T10; mean age: 34.1; mean DOI: 8.1 yrs) 3) 7 SCI subjects with implanted Brindley implant (6M 1F; C5-T3; mean age: 36.3; mean DOI: 7.4 yrs; mean time since implant: 2.6 yrs) **Treatment** Brindley anterior sacral root stimulator implant **Outcome Measures:** Oro-caecal and oro-anal transit time, fecal water content, and frequency of defecation	1. There was no significant difference in mean (SEM) oro-caecal times between the AB group (2.95 (0.15) hrs) and the SCI group (3.4 (0.34) hrs) or between the AB group and the Brindley stimulator group (3.4 (0.34)). 2. Paraplegics in stimulator group (0.78 (SEM=0.08) days) had a significant increase in defecation frequency compared to the SCI control group (0.37 (0.07)). 3. There was a non-significant trend towards a more rapid CTT in the stimulator group compared to the SCI group.
MacDonagh et al. 1990; UK Pre-post N=12	**Population:** Complete supraconal spinal cord lesions, 9M 3F, mean age: 33 (range: 21-49), 10 thoracic, 2 cervical, > 2 years post-injury **Treatment:** Brindley-Finetech intradural sacral anterior root stimulator implant **Outcome Measures:** full defecation	1. 6 patients achieved full defecation with implant and manual help was no longer required 2. Time taken to complete defecation was reduced 3. All were free from constipation

Discussion

A variety of methods using electrical or magnetic stimulation devices have been tested to determine whether or not they can improve bowel management outcomes in individuals with SCI.

The use of functional magnetic stimulation decreased mean colonic transit time (Tsai et al. 2009; Lin et al. 2002; Lin et al. 2001), as did stimulation of the abdominal muscles (Hascakova-Bartova et al. 2009; Korsten et al. 2004,). While preliminary results for posterior tibial nerve stimulation in individuals with SCI appear promising, it is important to note that the statistical significance of the improvements in clinical and physiological parameters were not reported and the study involved only two participants (Mentes et al. 2007).

In terms of implanted electrical stimulation systems, Binnie et al. (1991) found that an implanted Brindley (sacral anterior root) stimulator did not reduce oro-caecal time for individuals with SCI, however, subjects in the stimulator group did experience a significant increase in defecation compared to the control SCI group (Binnie et al. 1991).

Subsequent studies using sacral anterior root stimulation yielded improvements in bowel function, including better spontaneous evacuation (Lombardie et al. 2011; Sievert et al. 2010; Chia et al. 1996), reduced bowel program times (Kachourbos and Creasey 2000, Valles et al. 2009, Lombardi et al. 2009), elimination of autonomic dysreflexia related to bowel management (Kachourbos and Creasey 2000), elimination of manual help for defecation (Macdonagh et al. 1990). Both Holzer et al. (2007), and increased quality of life (Sievert et al. 2010; Lombardi et al. 2011; Lombardi et al. 2009; Holzer et al. 2007; Kachourbos and Creasey 2000). Jarrett et al. (2005) found reduced number of incontinence episodes through the use of sacral nerve stimulation, but conflicting evidence on the effects on resting and squeeze anal canal pressures (Lombardi et al, 2011; Holzer et al. 2007, Jarrett et al. 2005). Gstaltner et al. (2008) found that sacral nerve stimulation improved fecal continence, quality of life, and deliberate retention of faeces in their study among subjects with cauda equine syndrome. Finally, the Praxis FES system increased the frequency of defecation and decreased the time required for bowel evacuation in one subject (Johnston et al. 2005).

Worsoe et al.'s (2013) review of nerve stimulation techniques in neurogenic bowel dysfunction viewed neurostimulation as a way of 're-establishing neurogenic control and alleviating symptoms'. They reported that the sacral anterior root stimulator improves bowel function in some patients with complete SCI while sacral nerve stimulation can improve function in selected patients with a variety of incomplete neurologic lesions. They also suggest that peripheral stimulation using electrical stimulation or magnetic stimulation may offer non-invasive treatment alternatives for neurogenic bowels. However, they concluded that due to the lack of research evidence required to support informed choice, the latter techniques should be reserved for research at present.

Conclusions

There is level 1b evidence (from one RCT) (Korsten et al. 2004) that electrical stimulation of the abdominal wall muscles can improve bowel management for individuals with tetraplegia.

There is level 2 evidence (from one prospective controlled trial) (Binnie et al. 1991) that supports the use of sacral anterior root stimulation to reduce severe constipation in complete SCI.

There is level 4 evidence (from three pre-post studies) (Tsai et al. 2009, Lin et al. 2001, 2002) that functional magnetic stimulation may reduce colonic transit time in individuals with SCI.

There is level 4 evidence (from one pre-post study with two subjects) (Mentes et al. 2007) that posterior tibial nerve stimulation improves bowel management for those with incomplete SCI.

There is level 4 evidence (from one pre-post study with two subjects) (Johnston et al. 2005) that the Praxis FES system increases the frequency of defecation and decreases time required for bowel care in individuals with SCI.

Electrical stimulation of the abdominal wall muscles can improve bowel management for individuals with tetraplegia.

Functional magnetic stimulation may reduce colonic transit time in individuals with SCI.

Sacral anterior root stimulation reduces severe constipation in individuals with SCI.

3.7 Bowel Irrigation Techniques

Transanal irrigation is a process of facilitating evacuation of stool from the bowel by passing water (or other liquids) in via the anus in a quantity sufficient to reach beyond the rectum into the colon. Pulsed water irrigation uses an electrical pump to deliver intermittent, rapid pulses of warm water into the rectum/colon to break up stool and to stimulate peristalsis (Puet et al. 1997). The enema continence catheter was a specially designed catheter with an inflatable balloon, originally developed by Shandling & Gilmour (1987) for bowel management in individuals with spina bifida. The catheter was inserted into the rectum and the balloon inflated to hold the catheter in place. After the irrigation was administered under gravity, the balloon was deflated, the catheter removed and the bowel contents emptied. In 2006 Christensen et al. assessed the use of the newly developed Peristeen Anal Irrigation system (Coloplast A/S, Kokkedal, Denmark). This system consists of a rectal balloon catheter, a manual pump, and a water container. The catheter is inserted into the rectum and the balloon inflated to hold the catheter in place while tap water is administered using the manual pump (Christensen et al. 2006).

Antegrade irrigation introduces water to the colon (caecum) via a surgically formed non-reflux stoma. Irrigation may be delivered via the stoma using a manual or powered pump, or by gravity. The Malone antegrade continence enema (MACE or ACE) is a continent catheterizable stoma, connecting from the external abominal wall to the caecum, through which a catheter is inserted. An enema can then be given via the catheter

During both transanal and antegrade irrigation a rectal balloon catheter or rectal cone without a balloon is placed into the rectum, and removed once irrigation is completed for controlled voiding of the rectum.

Table 11a: Systematic Review on Irrigation Techniques for Neurogenic Bowel

Authors; Country **Date included in the review** **Total Sample Size** **Types of Articles** **Score**	**Methods** **Databases** **Level of Evidence**	**Conclusions**
Christensen & Krogh 2010 Denmark Systematically reviewed articles up until August 2009 N=27 studies (4 studies with SCI patients) **Level of evidence:** Methodological quality not assessed **Type of study:** 1 multi-centre, RCT (SCI); all others had no control AMSTAR: 3	**Method:** Systematic literature search for published reports on transanal irrigation was conducted. Subjects of interest were self-administered transanal irrigation, indications, techniques, outcomes, modes of action, complications, quality of life and quality of methods used. **Databases:** Medline, Embase, CINAHL, Cochrane Library, completed studies from the internet-based trial register (www.clinicaltrials.gov)	1. 17 studies evaluated transanal irrigation in adults; of these, 4 were studies with SCI patients. Treatment was regarded as successful in 53% of all cases; categorized by predominant symptom, success was achieved in constipation (45%), fecal incontinence (47%) and in the mixed symptom group (59%). 2. In a multi-centre RCT with SCI patients, patients treated with transanal irrigation had fewer complaints of constipation, less fecal incontinence, improved symptom-related QoL and reduced time consumption on bowel management than patients using best supportive bowel care without irrigation. Also, symptoms of AD were lower in this study, suggesting transanal irrigation may have a protective effect against AD. 3. A significantly better symptom-related QoLwas found in the irrigation group compared with patients treated with a conservative bowel regime w/o irrigation

Authors; Country Date included in the review Total Sample Size Types of Articles Score	Methods Databases Level of Evidence	Conclusions
		for the domains 'coping/behavior' and 'embarassment'. 4. A cost-effectiveness analysis with an SCI population indicates that transanal irrigation is cheaper and more effective than conservative bowel management, when taking into account aggregate costs of carer help, treatment of UTIs and associated loss of production productivity.
Emmanuel 2010 UK Systematically reviewed articles (no dates specified) N=23 studies (6 SCI) **Level of evidence:** Strengths and limitations were assessed for each study **Type of study:** 1 RCT, the rest were retrospective or observational AMSTAR: 2	**Method:** Systematic literature search for published reports on TAI in NBD subjects. No restrictions on articles by size or design. **Databases:** Pubmed	1. In a RCT of TAI with Peristeen compared with conservative bowel management, significant results in favor of TAI were found for all outcome measures (both symptom burden and QoL). 2. At the end of the RCT, 20/45 patients originally randomized to conservative management switched to TAI; at 10-week follow-up, the outcomes of the initial report were confirmed. 3. Another study reported 68% success for fecal incontinence and 63% for constipation with Peristeen and tap water. 4. 2 studies each with follow-up of nearly 10 years have described the successful long-term use of TAI in the SCI population. For patients with traumatic SCI, the success rates were 50% for complete injuries, 58% for high incomplete injuries and 53% for low incomplete injuries. The second long-term follow-up reported success for 62% of patients with SCI.

Table 11b: Consensus Review on Irrigation Techniques for Neurogenic Bowel

Authors; Country Total Sample Size Types of Articles Score	Methods Databases Level of Evidence	Conclusions
Emmanuel et al. 2013; UK (international panel of experts) N=20 non-pediatric articles	**Methods:** a consensus group of specialists from a range of nations (Denmark, France, Germany, Italy, the Netherlands, UK) and disciplines (physicians, surgeons, physiology experts, rehab specialists) who have experience in prescribing and monitoring patients using TAI assimilated emerging literature and clinical experience, reaching consensus through a round table discussion process. **Databases:** PubMed, Athens	1. Indications for TAI include: patients with NBD, primary or secondary functional bowel disorders. Contraindications for TAI include: stenosis, colorectal cancers, inflammatory bowel diseases, acute diverticulits, ischaemic colitis. 2. Optimal patient selection: conservative treatment including biofeedback should be tried without success before TAI is performed. Low rectal volume at urge to defecate and low maximal rectal capacity were significantly associated

Authors; Country Total Sample Size Types of Articles Score	Methods Databases Level of Evidence	Conclusions
		with a successful outcome of TAI. 3. Clinical examination and preparation: a specialist health-care professional should be consulted before TAI. Bowel diaries and symptom scoring systems should be used. Fecal impaction must be excluded and treated before starting TAI. 4. Patient training: comprehensive training is essential - written info should be available, training a patient until they are comfortable with irrigation is necessary. Patients should be taught to recognise the symptoms of colonic perforation and what actions to take.

Table 12: Irrigation Techniques for Neurogenic Bowel after Spinal Cord Injury

Author Year; Country Score Research Design Total Sample Size	Methods	Outcome
Christensen et al. 2006; Denmark PEDro =7 Randomized control trial N=87	**Population:** 1) TAI group: ≥T9: 3 complete, 5 incomplete; T10-L2: 1 complete, 1 incomplete; L3-S1: 1 incomplete); Age: mean 47.5 yrs; 29M 13F. 2) Conservative bowel management (CBM) group: ≥T9: 22 complete,11 incomplete; T10-L2: 1 complete, 3 incomplete; L3-S1, 8 incomplete Age: mean 50.6yrs; 33M 12F **Treatment:** TAI (Peristeen Anal Irrigation system) or conservative bowel management (Paralyzed Veterans of America clinical practice guidelines) for 10 weeks. **Outcome Measures:** Cleveland Clinic constipation scoring system (CCCSS), St. Mark's fecal incontinence grading scale (FIGS), American Society of Colon and Rectal Surgeons fecal incontinence score (symptom-related QOL scale), NBD score.	1. The TAI group had significantly improved scores over the CBM group for the following scales: CCCSS: TAI=10.3(4.4); CBM=13.2(3.4) FIGS: TAI= 5(4.6); CBM=7.3(4) NBD: TAI=10.4(6.8); CBM=13.3(6.4) 2. TAI group scored non-significantly better on 2/4 domains of the symptom-related quality-of-life tool and significantly better on the domains coping/behaviour (TAI=2.8(0.8) vs CBM=2.4(0.7)) and embarrassment (TAI=3.2(0.8) vs CBM=2.8(0.9)). 3. Improvement found in the TAI group as a whole was not confined to the more physically able patients 4. At weeks 7-10 subjects had reduced time spent on bowel management each day, and reported being less dependent on help 5. The reported frequency of urinary tract infection during weeks 1-10 was lower in the TAI group (TAI=5.9%, CBM=15.5%).
Kim et al. 2013; Korea Longitudinal N=52	**Population:** Level of injury**:** 28 tetraplegics, 24 paraplegics; 41M 11F; Mean (SD) age: 44.5 (11.0) yrs; mean (SD) DOI: 92.9 (118.4) months **Treatment:** Transanal irrigation (TAI) **Outcome Measures:** Compliance rate, questionnaire on demographics, bowel care habits, frequency and time needed to defecate,	1. Compliance with the use of TAI at 1, 3, and 6 months was 31/52 (59.6%), 25/52 (48.1%) and 18/52 (34.6%). 2. At 6 months, the noncompliant group contained a higher proportion of tetraplegics than paraplegics and a higher need for assistance during

Author Year; Country Score Research Design Total Sample Size	Methods	Outcome
	intestinal symptoms, need for assistance during bowel management, participant satisfaction and quality of life, adverse events	bowel management. At 6 months, 6/28 (21.4%) of tetraplegia patients and 12/24 (50%) paraplegic patients were using TAI. 3. In the compliant group, defecation time decreased from baseline to 6 months and quality of life increased from baseline to 6 months.
Faaborg et al. 2009; Denmark Post-test N = 211	**Population:** neurogenic bowel dysfunction 96M 115F; age: median 49yrs, range 7-81 yrs, who were introduced to transanal irrigation between 1994-2007. 74 traumatic SCI participants; 10 high complete, 12 high incomplete, 14 low complete, 38 low incomplete. **Treatment:** TAI (Enema continence catheter; same as that used in Christensen et al. 2000) **Outcome Measures:** Rate of success (treatment was considered successful if the patient is currently using TAI, if the patient used TAI until he/she died, or if the patient's symptoms resolved while using TAI) as evaluated by a questionnaire, as well as the patient's medical records; incidence of bowel perforation and other side effects	1. Successful outcomes in 98 (46%) of subjects after a mean follow-up of 19 months (range 1-114 months) 2. Dropout rate of 20% in the first 3 months of using TAI 3. Success rate 3 years after introduction of TAI was 35% 4. The male gender, mixed symptoms (patients suffering from both constipation and fecal incontinence), and prolonged colorectal transit times were significantly correlated with successful outcomes 5. Chance One non-lethal bowel perforation occurred in approximately 50,000 irrigations (0.002%), whereas minor side effects were observed in 48%. 6. Other minor side effects (such as abdominal pain, minor rectal bleeding, and general discomfort) were observed in 48% of subjects
Worsoe et al. 2008 Denmark Case series N = 80	**Population:** 64F 16M; Age: mean (range) 51 (17-84) yrs. Main symptom was constipation for 48 participants, fecal incontinence for 20 and a combination of both in 12. **Treatment:** Antegrade colonic enema (ACE), or ACE combined with colostomy **Outcome Measures:** A 44-item questionnaire, including whether the patient is still using ACE and if not, why; functional results and side effects of ACE; overall satisfaction with bowel function and quality of life; success of treatment, defined as subjects still using ACE or bowel symptoms resolved because of ACE	1. 69 subjects were available for follow up, of whom 43 were still using ACE and 8 had their symptoms resolved; ACE success rate was 74% 2. Complications occurred in 30 subjects, including wound infection, urinary tract infection, stenosis of the appendicostomy, and problems with catheterization 3. 34 of the 43 patients still using ACE were satisfied or very satisfied with the results; on a 0-100 scale, mean values for subjective bowel function was 12 before and improved to 81 after ACE
Christensen et al. 2008; Europe Pre-post N = 62	**Population:** 45M 17F; mean (SD) age: 47.5 (15.5) yrs; level of injury: supraconal for 61, conal/cauda equina (S2-S4) for 1. 55/62 completed the study **Treatment:** TAI (Peristeen Anal Irrigation) for a 10-week period **Outcome Measures:** Cleveland Clinic constipation scoring system (CCCSS), St Mark's fecal incontinence grading system (FIGS), Neurogenic bowel dysfunction (NBD) score (higher scores = worse outcomes)	1. Subjects' CCCSS mean scores significantly improved from 13.5 to 10.2. 2. Subjects' FIGS mean scores significantly improved from 8.5 to 4.5. 3. Subjects' NBD mean scores significantly improved from 15.3 to 10.8. 4. Peristeen Anal Irrigation significantly improved constipation, anal

Author Year; Country Score Research Design Total Sample Size	Methods	Outcome
		continence, and symptom-related quality of life in SCI subjects
Del Popolo et al. 2008; Italy Pre-post N = 36	**Population:** SCI patients with severe NBD and unsatisfactory bowel management; 32/36 completed the study. Cause of SCI: 42.4% trauma, 36.4% spina bifida, 6.1% MS, 3% surgery, 9.1% other, 3% not recorded. 39.4% sensory complete, 42.4% sensory incomplete, 18.2% not specified. **Treatment:** TAI (Peristeen Anal Irrigation) for three weeks **Outcome Measures:** Quality of life questionnaire (scale and nominal variables), subjects' opinions on their intestinal functionality, use of pharmaceuticals, dependence on caregivers, incidence of incontinence and constipation, abdominal pain or discomfort	1. Significant increase in the scores on the quality of life questionnaire, and on intestinal functionality opinion scores. 2. Significant decrease in abdominal pain or discomfort. For the statement regarding abdominal pain or discomfort before or after evacuation, before: 9 answered never, 5 rarely, 6 occasionally, 6 often, 7 always; after: 24 never, 6 rarely, 3 occasionally. 3. Significant decrease in incidence of fecal or gas incontinence. For the statement regarding gas incontinence, Before: 10 answered never, 9 rarely, 8 occasionally, 3 often, 2 always; After: 15 never, 11 rarely, 5 occasionally, 1 often, 1 always. 4. Significant improvement of constipation (63% of subjects experiencing constipation reported improvements). For the statement regarding difficult/painful exertion in connection with evacuation, Before: 5 answered never, 5 rarely, 4 occasionally, 10 often, 9 always; After: 21 never, 9 rarely, 3 occasionally, 1 often. 5. 28.6% of subjects reduced or eliminated their use of pharmaceuticals
Teichman et al. 2003; USA Retrospective chart review N=6; 3 SCI subjects	**Population:** (for N=3 SCI) Level of injury: T5 complete, C6 complete, C7 incomplete; all males; Age: mean (range) 36 (29-47) yrs; **Treatment:** Malone antegrade continence enema (MACE) with mean follow-up 4.5 years **Outcome Measures:** Bowel incontinence; subjective patient satisfaction (patients were asked: "do you consider the surgical procedure beneficial to you" and "if you could do the ACE procedure again, would you?")	1. 2/3 subjects experienced fecal incontinence prior to the operation. Post-operatively, both these subjects became continent 2. All 3 subjects were satisfied with their outcomes and rated their quality of life higher after their MACE procedure compared with beforehand. 3. All 3 subjects experienced prolonged toileting pre-operatively as a result of bowel status. Post-operatively, the group had a significant reduction in their toileting times (pre-ACE mean (SD) time: 190(45) vs post-ACE: 28(20) min).
Christensen et al. 2000; Denmark Retrospective interviews and case series N=29; 19 SCI subjects	**Population:** 1) TAI (enema continence catheter): N=21 subjects (15/21 were SCI); 10M 11F; Age: mean (range) 39.9 (7-72) yrs; for SCI subjects: Level of injury: 3 supraconal (T2 incomplete, T4 complete, T11 complete), 12 incomplete conal or cauda equina injuries; follow-up: mean (range) 16 (1-51) months	1. Overall success with TAI was found in 12/21 patients (57%). In patients with fecal incontinence, TAI was successful in 8/11 (73%), while 4/10 (40%) with constipation were successfully treated. 2. Overall success with the MACE was found in 7/8 (87%) patients. 3. Successful treatment with TAI or the

Author Year; Country Score Research Design Total Sample Size	Methods	Outcome
	2) MACE: 8 patients, (4/8 were SCI); 3M 5F; Age: mean 32.8 years, range 15-66; 2 supraconal SCIs (C5-6 and T2, incomplete); mean follow-up 38 months, range 4-77 **Treatment:** TAI (enema continence catheter) vs. MACE (out of 8 MACE patients, 3 had tried ECC previously) **Outcome Measures:** questionnaire on colorectal function, practical procedure, impact on daily living and quality of life, general satisfaction of the patient with the treatment	MACE was followed by significant improvement in quality of life
Teichman et al. 1998; USA Retrospective chart review N=7; 4 SCI subjects	**Population:** (for N=4 SCI subjects) Level of injury: 2 C6, 1 C7, 1 T5; all males; Age: mean (range) 32.5 22-47yrs; Mean follow-up: 11 months **Treatment:** MACE **Outcome Measures:** Number of fecal incontinence episodes per week, time for evacuation, bowel management episodes attempted	1. 3/4 SCI subjects experienced fecal incontinence prior to the operation. All became continent as a result of the operation. 2. Pre-operatively, SCI subjects' toileting times ranged from 1-4 hours as a result of their bowel status. Post-operatively, these subjects were able to evacuate within 30 minutes or less. 3. Autonomic dysreflexia secondary to neurogenic bowel was resolved post-operatively.
Puet et al. 1997; USA Case series N=173	**Population:** 15 complete tetraplegia, 28 incomplete tetraplegia, 35 complete paraplegia, 95 incomplete paraplegia; 31 patients with pulsed irrigation evacuation (PIE). **Treatment:** Pulsed TAI:. intermittent, rapid pulses of warm water to break up stool impactions and stimulate peristalsis. **Outcome Measures:** Efficacy of technique (percentage success in removing stool), outpatient use	1. Successful in removing stool in all but three patients. 2. 11 patients had multiple procedures. 3. 162 procedures were performed on 4 outpatients on a regular basis because they otherwise could not develop an effective bowel routine with the standard digital stimulation, suppositories, or mini enemas.

Discussion

Two review papers published in 2010 looked at transanal irrigation in the neurogenic population (Emmanuel 2010) and both the neurogenic and wider population (Christensen & Krogh 2010) respectively.

Both reviews concluded that the use of transanal irrigation resulted in significant improvements in incontinence, constipation, time spent on bowel care, autonomic symptoms around bowel management and quality of life, in comparison to conservative management in individuals with SCI. Irrigation was found to be a safe procedure, as the risk of bowel perforation was approximated as 1/50,000 irrigations. No adverse changes in rectal or colonic function were associated with irrigation use. However, in the long term a significant proportion of users stop using irrigation. The cause of this is not clear but thorough preparation and training for irrigation and continuing support whilst establishing a new regimen are thought to improve compliance.

An international group of specialists from a range of disciplines, experienced in transanal irrigation, have recently published a consensus review (Emmanuel et al. 2013) that provides guidance regarding patient selection, indications and contraindications for transanal irrigation and a step-by-step approach to treatment and follow-up. Absolute contraindications include anal or rectal stenosis, active inflammatory bowel disease, acute diverticulitis, colorectal cancer, ischaemic colitis, rectal surgery within the previous 3 months or endoscopic polylectomy within the previous 4 weeks. Relative contraindications include severe diverticulosis, long term steroid medication, painful anal conditions, planned or current pregnancy, and severe autonomic dysreflexia. Fecal loading/impaction should be treated before irrigation is instigated. No clear patient selection criteria have been identified; any individual whose bowel management is ineffective, lacks contraindications above, and who is suitably motivated may benefit from transanal irrigation. The importance of training the patient and their caregiver, as well as providing follow up support while establishing an individualized program is emphasized.

The evidence for irrigation is mostly in individuals with chronic SCI. There is a need to explore its potential in the subacute rehabilitation phase. Further research is also required to determine the cause of the reduction in use of irrigation over time and how this can be improved, and to develop clear patient selection criteria.

In individuals with SCI for whom transanal irrigation is ineffective or inappropriate, the Malone antegrade continence enema (MACE) can eliminate fecal incontinence (Worsoe et al. 2008; Teichman et al. 2003; Christensen et al. 2000; Teichman et al. 1998), reduce time spent on bowel care (Worsoe et al. 2008; Teichman et al. 2003; Teichman et al. 1998), improve quality of life (Teichman et al. 2003; Christensen et al. 2000), resolve autonomic dysreflexia secondary to the neurogenic bowel (Teichman et al. 1998), and successfully treat constipation (Christensen et al. 2000; Teichman et al. 2000).

Christensen et al. (2000) compared the efficacy of Malone antegrade continence enema with the enema continence catheter and reported successful treatment of fecal incontinence, slow transit or constipation, and obstructed defecation in persons with SCI.

Conclusion

There is level 4 evidence (from one case series) (Puet et al. 1997) that supports using pulsed water irrigation (intermittent rapid pulses) to remove stool in individuals with SCI.

There is level 1b evidence (from one RCT) (Christensen et al. 2006) that supports the use of transanal irrigation (Peristeen Anal Irrigation system) over conservative bowel treatment (as outlined by the Paralyzed Veterans of America clinical practice guidelines) in individuals with chronic SCI and bowel management problems.

There is level 4 evidence (from one case series, one cross-sectional, and three non-randomized cohort studies) (Del Popolo et al 2008, Christensen et al 2008, Faaborg et al 2009, Kim et al 2013) that supports the use of transanal irrigation to manage neurogenic bowel dysfunction.

There is level 4 evidence (from four retrospective reviews) (Teichman et al. 1998; Christensen et al. 2000; Teichman et al. 2003, Worsoe et al. 2008) that the Malone Antegrade Continence Enema successfully treats neurogenic bowel dysfunction.

There is level 4 evidence (from one retrospective review) (Christensen et al. 2000) that the enema continence catheter can be used to treat neurogenic bowel dysfunction.

Transanal irrigation can improve all bowel management outcomes in individuals with chronic neurogenic bowel dysfunction following SCI.

The Malone Antegrade Continence Enema is a safe and effective treatment for significant GI problems in persons with SCI when conservative and transanal irrigation are unsuccessful or inappropriate.

Pulsed water transanal irrigation may help to remove stool in individuals with SCI.

3.8 Prokinetic Agents

Chronic constipation is a common problem after SCI, with a prevalence of up to 80% of affected individuals (Krogh et al. 2002). The presence of constipation in patients with SCI with slow transit times has been well-documented (Geders et al. 1995).

Five studies exploring the use of cisapride for neurogenic bowel management have been removed from this review as the drug is no longer available.

Table 13: Treatment Studies Using Pharmacology for Neurogenic Bowel after SCI

Author Year; Country Score Research Design Total Sample Size	Methods	Outcome
Rosman et al. 2008; USA PEDro = 8 Crossover RCT N = 7	**Population:** 7 SCI subjects with defecatory problems (mean (SD) age: 46.9 (3.4) yrs, range 30 – 56 yrs); 4 cervical, 3 thoracic. **Treatment:** injections of neostigmine (2 mg) and glycopyrrolate (0.4 mg) for 1 week, wash-out period for 1 week, and placebo for 1 week, in random order **Outcome Measures:** Total bowel evacuation time; time to first flatus; time to beginning of stool flow; time to end of stool flow.	1. Compared with placebo, neostigmine/glycopyrrolate significantly reduced the total bowel evacuation time (mean (SD)) from 98.1 (7.2) min to 74.8 (5.8) min 2. Neostigmine/glycopyrrolate significantly reduced the mean (SD) time to first flatus from 56.9 (5.4) min to 21.8 (4.5) min 3. Neostigmine/glycopyrrolate significantly reduced the mean (SD) time to beginning of stool flow from 69.8 (2.8) to 42.3 (6.4) min, and time to end of stool flow from 80.3 (4.0) to 53.3 (8.3) min.
Krogh et al. 2002; Denmark PEDro = 7 Double blind RCT N=22	**Population:** mean (SD) age: 34.7 (2.5) yrs (placebo), 36.5 (3.9) yrs (1mg group), 44.3 (3.1) yrs (2mg group). No information on level of injury was reported. **Treatment:** Subjects randomized with double blind design to treatment with prucalopride 1mg or placebo, taken once daily for 4 wks. A 2nd group of subjects was randomized to prucalopride 2mg or placebo for 4wks **Outcome measures:** constipation; urinary habit; constipation severity and symptoms; colonic transit times	1. Compared with baseline, constipation severity decreased with prucalopride. The VAS score for treatment efficacy showed a clear dose response (medians 4, 52, and 73 for placebo, 1 and 2 mg, respectively). 2. Self-report diary showed an improvement in average weekly frequency of all bowel movements over 4 wks within the 2 mg group (median 0.6). 3. 3 subjects (2 mg group) reported moderate/severe abdominal pain and 2 discontinued treatment. Adverse events (AEs) were reported by 6/7 in the placebo group, and by 7/8 and 6/8 in the 1 and 2mg groups. The most common AEs were gastrointestinal (flatulence, abdominal pain and diarrhea).

Author Year; Country Score Research Design Total Sample Size	Methods	Outcome
Korsten et al. 2005; USA PEDro = 6 RCT N=13	**Population:** Level of injury: C4-T12 (5 tetraplegics, 8 paraplegics; 12/13 motor complete, 5/13 sensory incomplete); Age: mean (range) 46 (25-69)yrs; Duration of injury: mean (range) 14 (1-31)yrs **Treatment:** On different days, subjects received, in a randomized, double-blinded design, one of three intravenous infusions (normal saline, 2 mg neostigmine, or 2 mg neostigmine and 0.4 mg glycopyrrolate) **Outcome Measures:** time to bowel evacuation using barium paste	1. Neostigmine and the combination of neostigmine and glycopyrrolate both caused a similar expulsion of the stool, which was greater than with normal saline (median score 3 vs. 4 vs. 0, respectively) 2. Mean time to expulsion was 11.5 min (range 5-20 min) after neostigmine and 13.5 min (range 4-23 min) after the combination 3. There was no correlation between the level of SCI and likelihood of bowel evacuation with any of the infusions
Cardenas et al. 2007; USA PEDro = 6 RCT N=91	**Population:** 91 subjects with motor-incomplete SCI randomized to three groups: (I) Fampridine, sustained release, 25 mg bid: Level of injury: 23 cervical, 7 thoracic; AIS grade: 14 C, 16 D; 22M:8F; Age: mean (range) 44 (23-66)yrs; Duration of injury: mean (range) 8.3 (1-30)yrs (II) 40 mg bid: Level of injury: 24 cervical, 6 thoracic; AIS grade: 12 C, 18 D 26M:,4F; Age: mean (range) 42 (21-67)yrs; Duration of injury: 10.8 years, range 1-35; (III) Placebo: Level of injury: 26 cervical, 5 thoracic; AIS grade: 18 C, 13 D; 24M:7F; Age: mean (range) 38 (19-61)yrs; Duration of injury: mean (range) 8.3 (1-37)yrs **Treatment:** Drug treatment (Fampridine orally 25mg bid or 40mg bid) or placebo for 8 weeks **Outcome Measures:** Number of days with bowel movement, Subject Global Impression (SGI), Ashworth	1. A significantly larger number of subjects in the 25 mg bid (6/30 subjects) and 40 mg bid (7/30 subjects) groups had an increase in the number of days with bowel movements compared to subjects in the placebo group. Number of days increase not reported. 2. In total 78% of subjects completed the study. More (13/30) discontinued from Group II than Group I (4/30) and Group III (3/31). The most frequent AEs were hypertonia, generalized spasm, insomnia, dizziness, asthenia, pain, constipation, and headache. One subject in Group II suffered a seizure. 3. SGI changed significantly in favor of Group I (mean=4.5). Group II had a mean of 3.6 and Group III had a mean of 3.9. 4. Subgroup analysis of subjects with baseline Ashworth scores >1 showed significant improvement in spasticity in Group I versus Group III (Ashworth mean score: Group I= 1.0; Group 2= 1.1; Group III= 1.2).
Segal et al. 1987; USA Prospective Controlled Trial N=28	**Population:** 11 subjects with tetraplegia, 9 subjects with paraplegia (all complete SCI), 8 able-bodied controls; Age range: 20-55yrs **Treatment:** subjects ingested a liquid meal, then within 2 weeks, ingested 2nd liquid meal while metoclopramide (10mg) was administered intravenously; gastric emptying (GE) was evaluated after each liquid meal **Outcome Measures:** half time of gastric emptying, gastric emptying patterns in the early and later phases	1. The mean GE half time for a liquid meal decreased in the subjects with tetraplegia from 104.8 min to 18.8 min after treatment with metoclopramide 2. The pretreatment mean GE of 111.5 min decreased to 29.1 min among the subjects with paraplegia.

Discussion

Prokinetic agents are presumed to promote transit through the GI tract, thereby decreasing the length of time needed for stool to pass through the intestines and increasing the amount of stool available for evacuation. Since constipation in patients with both acute and chronic SCI is considered primarily a consequence of prolonged colonic transit time, stimulating intestinal motility would appear to be a reasonable therapeutic approach. Segal et al. (1987) investigated the use of metoclopramide (a potent dopamine receptor antagonist with prokinetic properties) for enhancing gastric emptying in individuals with SCI. They found that impaired gastric emptying in patients with SCI can be significantly improved using metoclopramide. Improvement in constipation and increased frequency of bowel movement were also seen with the use of prucalopride - a novel, highly selective serotonin receptor agonist with enterokinetic properties that facilitates cholinergic and excitatory non-adrenergic, non-cholinergic neurotransmission (Krogh et al. 2002). Korsten et al. (2005) found that neostigmine (a reversible cholinesterase inhibitor) or the combination of neostigmine and glycopyrrolate administered intravenously improved stool expulsion over normal saline. Rosman et al. (2008) reported similar findings for the use of neostigmine and glycopyrrolate in combination over placebo. Finally, a study by Cardenas et al. (2007) reported an increase in the number of days with bowel movements in approximately one-fifth of the subjects given sustained-release fampridine (selective potassium channel blocker).

Conclusion

Prucalopride: There is level 1b evidence (from one RCT) (Krogh et al. 2002) that prucalopride increases stool frequency, improves stool consistency and decreases gastrointestinal GI transit time; higher doses (2mg/day) were associated with moderate/severe abdominal pain.

Metoclopramide: There is level 2 evidence (from one prospective controlled trial; N=20) (Segal et al. 1987) that intravenous administration of metoclopramide decreases time of gastric emptying.

Neostigmine: There is level 1b evidence (from one RCT) (Korsten et al. 2005) that neostigmine, administered with or without glycopyrrolate, leads to a greater expulsion of stool. There is level 1 evidence that neostigmine with glycopyrrolate decreases total bowel evacuation times and improves bowel evacuation.

Fampridine: There is level 1b evidence (from one RCT) (Cardenas et al. 2007) that fampridine can increase the number of days with bowel movements.

In very small studies prucalopride, metoclopramide, neostigmine, and fampridine have been found to improve constipation in individuals with SCI.

Prucalopride is not currently available the United States but is available in Canada and Europe. More research is required on prokinetic agents prior to their regular use in neurogenic bowel dysfunction.

3.9 Pharmacological Rectal Stimulants

Pharmacological rectal stimulants (suppositories and enemas) are a common component of a successful bowel management program, used by up to 60% of individuals with UMN bowel dysfunction (Coggrave 2009). The two most commonly used are the glycerin suppository, which provides a mild local stimulus and lubrication, and the bisacodyl (dulcolax) suppository, which provides a dose of stimulant laxative directly to the colonic mucosa producing peristalsis throughout the colon. Other options include sodium hydrogen carbonate suppositories, sodium citrate and glycerol micro-enema and docusate sodium micro-enema.

Table 14: Treatment Studies Using Suppositories for Neurogenic Bowel after SCI

Author Year; Country Score Research Design Total Sample Size	Methods	Outcome
House & Stiens 1997; USA PEDro = 7 RCT N=15	**Population:** 9 subjects with cervical injuries, 6 with thoracic injuries (11 complete, 4 incomplete); Age range: 26-61; Duration of injury: 3 months to 45 yrs **Treatment:** At each regularly scheduled bowel care session, insertion of either a 10 mg hydrogenated vegetable-oil base (HVB) or 10 mg polyethylene glycol base (PGB) suppository. Additionally, 10 subjects received 3 TVC (polyethylene glycol-based, glycerine, docusate sodium mini-enemas). **Outcome Measures:** time to flatus, flatus to stool flow, defecation period, time to transfer cystometrogram, intracolonic pressure, colonic motor and myoelectrical activity	1. Mean time to flatus (min): PGB (15) significantly less time than HVB (32) 2. Mean time from flatus to stool flow (min): No significant differences. HVB=6.7, PGB=5.5, TVC=3.9. 3. Defecation Period (mean in min): PGB (20) significantly less time than HVB (36). TVC=17 4. Total time for bowel program (mean in min): PGB suppositories (43) significantly decreased bowel care time compared to HVB (74.5). TVC=37.
Amir et al. 1998; USA Prospective Cohort N=7	**Population:** Level of injury: C4-T12, 6 subjects with tetraplegia, 1 subject with paraplegia; Age range: 21-76yrs; Duration of injury range: 2-25yrs **Treatment:** Each subject was studied after receiving one week of therapy with one of the following four modalities: 1) two bisacodyl suppositories, 2) two glycerin suppositories, 3) one mineral oil enema and 4) one docusate sodium mini enema (Theravac SB) daily. **Outcome Measures:** total colonic and segmental colonic transit times	1. Total colonic transit time (CTT) was significantly reduced with docusate sodium mini-enemas. Mean total CTT was 32.0, 34.5, 47.6 and 48.0 hrs with docusate sodium, mineral oil enema, bisacodyl suppositories and glycerin suppositories respectively. 2. There was no significant difference in total colonic transit times between docusate sodium and mineral oil enema, and both produced significantly shorter transit times compared to bisacodyl or glycerin suppositories. 3. Bowel evacuation time was least for docusate sodium mini-enemas (31.5 min). Mean evacuation time was 46.5, 57.6, and 63.5 min after mineral oil, glycerin and bisacodyl suppositories, respectively. 4. In terms of difficulty with evacuation, docusate sodium enema scored best in symptom reduction followed by, in descending order of efficacy, mineral oil enema, bisacodyl suppositories and glycerin suppositories.
Stiens et al. 1998; USA Prospective controlled trial N=14	**Population:** Level of injury: C3-L1 (4 incomplete, 10 with complete); All males; Age: mean 53.4yrs: Duration of injury: mean 18.3yrs **Treatment:** PGB vs. HVB bisacodyl suppositories at initiation of side-lying bowel care **Outcome Measures:** Time to flatus, flatus to stool flow, defecation period, clean up, total bowel care time	1. Time to flatus: HVB=31 min is significantly different from PGB=12 min Defecation period: HVB=58 min is significantly different from PGB=32 min; Total bowel care time is significantly different for: HVB=102 min, PBG=51.2 min ($p<0.0005$) 2. The numbers of digital stimulations required for the bowel care sessions was not significantly different from HVG and PGB: HVB=5.0, PGB=3.2

Author Year; Country Score Research Design Total Sample Size	Methods	Outcome
Frisbie 1997; USA Prospective controlled trial N=19	**Population:** Level of injury: T1-7 (15 cervical, 4 thoracic); Age: mean (range) 64 (41-81)yrs; Duration of injury: mean (range) 19 (3-51)yrs. **Treatment:** A PGB vs HVB bisacodyl suppository **Outcome Measures:** Average time for complete bowel evacuation	1. All patients experienced a shortening of bowel care time with PGB. Average time for bowel evacuation was 2.4 hours (range 1.0-4.5 hours) with HVB and 1.1 hours (range 0.3 to 1.8 hours) with PGB
Dunn & Galka 1994; USA Case Series N=14	**Population:** Level of injury: C5-L1, (5 tetraplegics, 9 paraplegics); Age: range 27-67yrs; Duration of injury: range 2-38yrs **Treatment:** Phase 1: bisacodyl suppositories for five bowel programs for baseline data. Phase 2: docusate sodium mini enema (Theravac SB) for the next five bowel programs. Phase 3: bisacodyl for five more bowel programs **Outcome Measures:** Self-reported diary including time of insertion of the rectal medication; time of first evacuation; time required to complete the first evacuation; other interventions used; bowel problems between bowel programs	1. 10 subjects complete all treatment phases. 2. Of these 10 subjects, the mean evacuation time was significantly reduced with Theravac SB (phase 2) compared to the mean times with both the bisacodyl interventions (phase 1 and 3) 3. No significant difference in evacuation time between the first (phase 1) and second (phase 3) bisacodyl interventions.

Discussion

Pharmacological rectal agents (suppositories or enemas) are commonly used by individuals with SCI to stimulate reflex evacuation at the time chosen for bowel care. They are an essential element of a bowel program for many individuals with upper motor neuron bowel though there is little evidence to support most of the suppositories and enemas used. However, the effectiveness of the hydrogenated vegetable oil-based bisacodyl suppositories compared to the polyethylene glycol-based suppositories has been examined. The total bowel care time with the polyethylene glycol-based suppository is significantly less (Stiens et al. 1998; Frisbie 1997; Dunn & Galka 1994) compared to hydrogenated vegetable oil based suppository. House and Stiens (1997) compared the effectiveness of hydrogenated vegetable-based, polyethylene glycol-based and docusate glycerin (mini-enema) in subjects with upper motor neuron lesions. Results showed a significant decrease in bowel care time using the polyethylene glycol-based suppository and the mini-enema as compared with the hydrogenated vegetable oil-based suppositories. Amir et al. (1998) found in a cohort of seven individuals with SCI that docusate sodium mini enema scored best in neurogenic bowel symptom reduction followed by, in descending order of efficacy, mineral oil enema, bisacodyl suppositories and glycerin suppositories.

Conclusion

There is level 1b evidence (from 1 RCT) (House and Stiens 1997) to support polyethylene glycol-based suppositories for bowel management. There is a clinically significant decrease in the amount of nursing time for persons requiring assistance and less time performing bowel care for the independent individual.

Polyethylene glycol-based bisacodyl suppositories (10 mg.) are more effective in stimulating reflex evacuation as part of abowel management program in persons with an upper motor neuron SCI than bisacodyl in vegetable oil suppositories.

4.0 Colostomy and Ileostomy

A stoma is a surgically formed opening between a body cavity, such as the colon or ileum, and the external body environment, such as the outer abdominal wall. After formation of a colostomy or ileostomy, stool flows through the stoma from the colon or intestines respectively, into a collecting device attached to the abdominal wall, thereby bypassing the rectum and anus. SCI individuals who undergo elective colostomy or ileostomy have usually exhausted all other appropriate bowel management options. The most common reasons for undergoing stoma surgery include prolonged bowel management episodes, unmanageable fecal incontinence, and constipation. Autonomic dysreflexia and pain associated with bowel evacuation, difficulties finding appropriate care, perianal disease and pressure ulcers close to the anus may also be reasons to choose a stoma for bowel management. Stoma for bowel management remains uncommon; one study suggested a prevalence in the UK of around 2.5% (Coggrave et al. 2009). There is no general consensus as to when colostomy should be performed in individuals. Aging and increased duration of SCI may contribute to bowel management difficulties (Faaborg et al 2008) and with increasing life expectancy amongst people with SCI, stoma may become a more common management choice in the future.

One systematic review examined studies that directly compared clinical, functional, QOL outcomes or satisfaction among individuals with a stoma to individuals using conservative means.

Table 15a: Systematic Review on Colostomy

Authors; Country Date included in the review Total Sample Size Types of Articles Score	Methods Databases Level of Evidence	Conclusions
Hocevar and Gray 2008; USA Reviewed published articles from January 1960 to November 2007 N= 6 n=203 SCI **Types of Articles:** 2 case-control 3 interviews 1 cross-sectional survey AMSTAR: 3	**Methods:** literature search for prospective and retrospective studies that directly compared clinical, functional, quality of life outcomes or satisfaction among patients with intestinal diversions to patients managed by conservative means. **Databases:** MEDLINE, CINAHL, Cochrane Database for Systematic Reviews, Google Scholar **Level of Evidence:** No formal validity assessment was described	1. Creation of an ostomy in selected patients provides equivocal or superior quality of life outcomes when compared to conservative bowel management 2. Both colostomy and ileostomy surgery significantly reduce the amount of time required for bowel management (Level of Evidence: 3). 3. Patients who undergo ostomy surgery tend to be satisfied with their surgery, and a significant portion report a desire to be counselled about this option earlier. 4. There are no clear advantages when functional, clinical, or quality of life outcomes associated with colostomy are compared to those seen in SCI patients undergoing ileostomy (Level of evidence: 4).

Table 15b: Colostomy after a Spinal Cord Injury

Author Year; Country Score Research Design Total Sample Size	Methods	Outcome
Coggrave et al. 2012; UK Retrospective self-report survey N=92	**Population:** 26 cervical (15 complete, 10 incomplete, 1 unknown), 61 thoracic (49 complete, 10 incomplete, 2 unknown), 1 missing data on level of injury; 64M:28F; Age: mean (SD) 56(9)yrs; duration of injury: mean (SD) 26(13)yrs; 91% colostomy, 9% ileostomy. **Treatment:** Retrospective analysis of a self-report postal survey of individuals with SCI who had a stoma for bowel management issues (five UK spinal centres) **Outcome Measures:** Tennessee Self-Concept Scale, Satisfaction with Life Scale, Hospital Anxiety and Depression Scale, 3 simple rating scales for satisfaction, ability to live with bowel dysfunction, and how much bowel care restricts life.	1. Subjects reported experiencing bowel difficulties for a mean (SD) time of 10 (10) years before surgery. 11% would've preferred surgery a year earlier, 28% up to 5 years earlier, 30% up to 10 years earlier and 32% earlier still. None suggested stoma formation was too early. 2. Subjects reporting an ileostomy were significantly more likely to need assistance than those with a colostomy. 3. Laxative use was reduced from 58 to 31% and dietary manipulation to assist bowel care was reduced significantly. 4. 83 (70%) reported they felt very positive about their stoma, whereas 2 subjects felt others avoided them due to the stoma. 5. For 23%, there was impact on personal relationships; 9 reported positive impact, 6 negative and 3 neutral.
Munck et al. 2008; Belgium Case-series N = 23	**Population:** 23 SCI subjects who had a colostomy in the digestive surgery department of Brugmann Hospital between Jan 1996 and Dec 2005 (age range 22-72). Level of injury: 13 dorsal, 7 cervical, 3 lumbar. **Treatment:** Colostomy **Outcome Measures:** Demographic information and medical information on the stoma formation and complications, collected from subjects' medical records; quality of life questionnaire.	1. 10 subjects had a stoma for perineal wounds 2. Average time spent on bowel care per week decreased from 5.95 hr prior to stoma formation to 1.5 hr after 3. Of the 10 patients, 3 reported cutaneous irritations and 1 reported detachment of the pocket 4. Of the 10 patients, 9 reported having much easier bowel care since the stoma formation, and 6 felt that the stoma had given them greater independence.
Luther et al. 2005; USA Cross-sectional N=370	**Population:** SCI subjects in 6 centers that were selected to be representative of the 23 Veteran Affairs SCI centers. Survey respondents with colostomies were matched to controls based on age, year of injury, classification of paralysis and marital status by calculating propensity scores. Comparison of 74 patients with a sample of 296 matched controls without colostomies. **Treatment:** Colostomy **Outcome Measures:** Bowel care-related items; quality of life.	1. No statistically significance differences were found in the demographic distributions for cases and controls. 2. No statistically significant differences were reported between the cases and the matched controls for any of the bowel care outcomes or bowel-related quality of life. Both groups reported low incidence of accidental/unplanned bowel movements and falls related to bowel care. 3. Mean responses to the quality of life items were generally very high; however, a large number of respondents continue to express dissatisfaction with bowel care. The cases had a much higher percentage of responses (55.7%) in the "very dissatisfied" category than did the controls (41.7%).
Branagan et al. 2003; UK Retrospective chart review	**Population:** 10 subjects with cervical SCI, 18 with thoracic, and 3 lumbar; Age at injury: average 28.9 yrs; Duration of injury: mean 17.1 years	1. The average time spent on bowel care per week decreased significantly from 10.3 hours to 1.9 hours after the colostomy. 2. 18/31 subjects felt the colostomy gave

Author Year; Country Score Research Design Total Sample Size	Methods	Outcome
N=32	**Treatment:** Medical records were reviewed for subjects who had a previous colostomy. **Outcome Measures:** Results of surgery	them greater independence. 3. 25 subjects wished they had been offered a stoma earlier. 4. No subjects wanted a stoma reversal.
Safadi et al. 2003; USA Retrospective chart review N=45	**Population**: 21 tetraplegics, 24 paraplegics; 44M 1F; Mean age 55.9yrs, **Treatment**: 20 right side colostomies (RC), 21 left side colostomies (LC), 7 ileostomies (IL) **Outcome Measures**: quality of life, colonic transit time, bowel care time	1. Colonic transit time was significantly longer in the right side colostomy compared to the left side colostomy and the ileostomy. 2. In all groups, quality of life increased (RC: 49 to 79, LC: 50 to 86, IL: 60 to 82 min) and bowel care time decreased (RC: 102 to 11 min, LC: 123 to 18 min, IL: 73 to 13 min).
Rosito et al. 2002; USA Case series N=27	**Population:** Level of injury: C4-L3 (17 complete, 10 incomplete); mean age: 62.9 yrs; 26M 1F; Duration of injury: 25.8yrs **Intervention:** Colostomy **Outcome Measures:** Quality of life questionnaire with 5 domains: physical health, psychosocial adjustment, body image, self-efficacy, and recreation/leisure	1. Quality of life improved significantly after colostomy. 2. All 27 patients were satisfied, 16 very satisfied 3. Colostomy reduced the number of hospitalizations caused by chronic bowel dysfunction by 70.4%. 4. After colostomy, the average amount of time spent on bowel care was reduced significantly from 117.0 min/day to 12.8 min/day. 5. Significant improvements were recorded in the areas of physical health, psychosocial adjustment, and self-efficacy.
Randell et al. 2001; New Zealand Case-control N=52	**Population:** 26 subjects with colostomy: 10 with cervical SCI, 16 with lumbar/lower thoracic SCI; age: 22-87yrs, matched with 26 subjects without colostomy. **Treatment:** Colostomy **Outcome Measures**: Burwood Quality of Life Questionnaire: 5 areas: systemic symptoms, and emotional, social, work and bowel function.	1. No significant difference in the group with a colostomy compared to the group without a colostomy in regard to their general well-being, emotional, social or work functioning.
Kelly et al. 1999; UK Retrospective chart review N=14	**Population:** Level of injury: C4-L2 (3 cervical, 10 thoracic, 1 lumbar); 12M 2F; Age at time of operation: mean (range) 54.8 (20-65) yrs; time from injury to stoma formation: mean (range)15 (2-37) yrs **Treatment:** 12 subjects underwent left iliac fossa end colostomy and 2 subjects right iliac fossa end ileostomy **Outcome Measures:** Time spent on bowel care per week; independence in bowel care; quality of life	1. Colostomy subjects (N=12): mean time spent on bowel care per week before stoma formation was 8.8 h (0.6-12.2) compared with 1.4 h (0.3-3.5) after; 50% of these patients were independent in bowel care before, 92% independent after; 10 patients claimed that the colostomy had a beneficial effect on their quality of life 2. Illeostomy patients (N=2): mean time spent on bowel care per week before ileostomy was 17.5 h and this was unchanged after ileostomy formation. 1 subject decreased the time he spent on bowel care from 28 h to 14 h; the other

Author Year; Country Score Research Design Total Sample Size	Methods	Outcome
		developed complications and his time increased from 7 h to 21 h.
Stone et al. 1990; USA Case Series N=7	**Population:** Level of injury: C4-T10; Age: mean 51.6yrs; Duration of injury: mean 15.7 years **Treatment:** Medical records were reviewed for subjects who had undergone a colostomy **Outcome Measures:** Efficacy of colostomy.	1. All seven subjects who had colostomy performed as an adjunct to the treatment of perianal pressure ulcers successfully healed their ulcers. 2. The amount of time spent on bowel care decreased dramatically in the patients with prolonged bowel care.
Frisbie et al. 1986; USA Cross-sectional N=20	**Population:** Level of injury: 9 cervical, 11 thoracic; 19M 1F; Age: median (range) 55 (27-75) yrs. Duration of the enterostomies at time of interview was, median (range): 11 months (3 months to 14 yrs) **Treatment:** A total of 24 enterostomies were carried out in 20 subjects: 17 sigmoid colostomies, 5 transverse colostomies, and 2 ileostomies. **Outcome Measures:** Bowel care time, bowel care frequency, bowel care related complaints, quality of life	1. Bowel care frequency increased from a median 3 times/week (range 2-7) before enterostomy to a median 7 times/week (range 4-14) after enterostomy 2. Bowel care duration diminished from a median 6 hours/week (range 0.7-14 hours) before enterostomy to a median 1 hour/week (range 1.3-7 hours) after enterostomy 3. The number of patients affected by bowel care related complaints pre- vs. post-operatively, respectively, were as follows: abdominal pain in 10 vs. 2, fecal leakage in 8 vs. 0, anorexia in 7 vs. 2, flatus in 9 vs. 4, sweating in 4 vs. 2 and odour in 4 vs. 5

Discussion

Stoma formation is a relatively safe, effective and well-accepted method of managing significant neurogenic bowel management problems in individuals with SCI. Research findings suggest that stoma reliably reduces the number of hours spent on bowel care (Munck et al. 2008; Branagan et al. 2003; Rosito et al. 2002; Kelly et al. 1999; Stone et al. 1990; Frisbie et al. 1986), reduces the number of hospitalizations caused by GI problems (Rosito et al. 2002) and bowel care-related complaints (Frisbie et al. 1986), simplifies bowel care routine (Frisbie et al. 1986), reduces fecal incontinence and improves quality of life (Coggrave et al. 2012; Munck et al. 2008; Safadi et al. 2003; Rosito et al. 2002; Kelly et al. 1999). Stoma increases independence, facilitates travel, elevates feelings of self-efficacy, and does not negatively affect body image (Branagan et al. 2003; Rosito et al. 2002). Stoma was well-received by patients and either met or exceeded their expectations (Rosito et al. 2002; Coggrave et al. 2012). Many SCI subjects wished to have the stoma done earlier (Coggrave et al. 2012, Branagan et al. 2003). There have been a few complications including increased in bowel times in one subject receiving an ileostomy (Kelly et al. 1999) and increased odor in one subject receiving an enterostomy (Frisbie et al. 1986). Overall current evidence supports the earlier education of individuals with SCI regarding the option of stoma for bowel management.

Conclusions

There is level 4 evidence (from six studies) (Frisbie et al. 1986; Stone et al. 1990; Kelly et al. 1999; Rosito et al. 2002; Branagan et al. 2003, Munck et al. 2008) that colostomy reduces the number of hours spent on bowel care.

There is level 4 evidence (from one retrospective pre-post study) (Frisbie et al. 1986) that colostomy greatly simplifies bowel care routines.

There is level 4 evidence (from one case study) (Rosito et al. 2002) that colostomy reduces the number of hospitalizations caused by gastrointestinal problems and improves physical health, psychosocial adjustment and self-efficacy areas within quality of life.

There is level 4 evidence (from one cross-sectional study) (Coggrave et al. 2012) that colostomy reduces need for laxative use and dietary manipulation to assist bowel care.

Elective stoma formation is a safe and effective treatment for significant neurogenic bowel management problems and perianal pressure ulcers in persons with SCI, and greatly improves their quality of life.

5.0 Assistive Devices

In addition to standard bowel protocols and pharmacological modalities, numerous devices were evaluated as means to improve bowel evacuation in individuals with SCI. These include a standing table and a modified toilet seat.

Table 16: Assistive Devices

Author Year; Country Score Research Design Total Sample Size	**Methods**	**Outcome**
Uchikawa et al. 2007; Japan Cross-sectional N=20	**Population:** 11 subjects with cervical, 7 with thoracic, and 2 with lumbar SCI; AIS level: 8 A, 4 B, 4 C, and 4 D; all male; Age: mean (range) 46.3 (18-73) yrs; all were at least 5 months post injury **Treatment:** Newly developed procedure to induce bowel movement involving a toilet seat equipped with an electronic bidet (provides water flow), a charge-coupled device (CCD) camera monitor and a light (facilitates location of anorectal area). **Outcome Measures:** Time required for successful bowel movement, amount of residual stool in rectum	1. Time needed for bowel management was shorter with the intervention than that with subjects' usual manner of bowel care 2. 35% (n=7) of subjects originally spent less than 30 minutes for usual defecation compared to 75% (n=15) with modified device 3. Residual stools found in 8/15 subjects who successfully defecated within 30 minutes with the device. 4. Success of defecation not related significantly with injury level or AIS impairment scale.
Hoenig et al. 2001; USA Case Report N=1	**Population:** 62-year-old male with T12/L1 AIS B paraplegia; time since injury = 36 years **Treatment:** Standing table for the treatment of constipation 1 hr/day, 5 days/wk for 1 month. **Outcome Measures:** Frequency of bowel movements and length of bowel care episodes.	1. The frequency of bowel movements nearly doubled (from 10 to 18) with the use of the standing table 2. The time spent on bowel care was reduced from 21 to 13 minutes

Discussion

Hoenig et al. (2001) reported the case of an individual with SCI who, through the use of a standing table, doubled the frequency of his bowel movements and reduced time spent on bowel care. Uchikawa et al. (2007) developed a new procedure to induce bowel movements using a toilet seat equipped with an electronic bidet that provides water flow to the anorectal area. A CCD camera and light are included to facilitate location of the anorectal area. The authors report that a reduction in the time needed for bowel management, with an additional 8 (40%) subjects who can complete defecation in less than 30 minutes.

Conclusion

There is level 5 evidence (from one case report with one subject) (Hoenig et al. 2001) that a standing table alleviates constipation in an individual with SCI.

There is level 4 evidence (from one cross-sectional study) (Uchikawa et al. 2007) that a newly developed washing toilet seat with a CCD camera monitor for visual feedback reduces time spent on bowel care.

There is limited evidence that a standing table may reduce constipation. There is limited evidence that a washing toilet seat with visual feedback may assist bowel care.

6.0 Summary

Neurogenic bowel dysfunction and associated morbidity is very common after SCI and can severely affect the quality of life of an individual with SCI. In addition, neurogenic bowel dysfunction complications can lead to increased use of health care resources, and while rarely fatal, contributes to a decrease in quality of life. For individuals with SCI neurogenic bowel dysfunction is of huge importance and yet research in this area of care is sadly lacking. Studies available frequently include small samples, are methodologically unsound and poorly reported. There is no evidence for the use of oral laxatives, little for rectal stimulants and few studies determine the best way to structure a bowel program. Developing an effective and acceptable bowel management program still relies largely upon trial and error and the experience of the healthcare professional supporting the patient. Further research is required in all areas of this field.

There is level 1b evidence (from one RCT; N=68) (Coggrave & Norton 2010) that systematic use of less invasive interventions does not reduce the need for oral laxatives or more invasive interventions such as rectal stimulants and manual evacuation.

There is also level 1b evidence (Coggrave & Norton 2010) that use of a multifaceted bowel management program may increase the duration of bowel management. This is in contrast with level 4 evidence (from three pre-post studies; aggregate N=65) (Coggrave et al. 2006; Correa and Rotter 2000; Badiali et al. 1997) that multifaceted bowel management programs may reduce GI transit time, incidences of difficult evacuations, and duration of time required for bowel management.

There is level 4 evidence (from one case series; N=11) (Cameron et al. 1996) that indicates high fibre diets may lengthen colonic transit time in individuals with SCI.

There is level 4 evidence (from one pre-post study; N=6) (Korsten et al. 2007) that digital rectal stimulation increases motility in the left colon.
There is level 4 evidence (from one pre-post study; N=24) (Ayas et al. 2006) that abdominal massage is ineffective for treating the neurogenic bowel.

There is conflicting level 4 evidence (from one pre-post study; N=20) (Hu et al. 2013) that abdominal massage is effective in reducing bowel movement time as well as dosage of glycerine enemas.

There is level 1b evidence (from one RCT) (Korsten et al. 2004) that electrical stimulation of the abdominal wall muscles can improve bowel management for individuals with tetraplegia.

There is level 2 evidence (from one prospective controlled trial) (Binnie et al. 1991) that supports the use of sacral anterior root stimulation to reduce severe constipation in complete SCI.

There is level 4 evidence (from three pre-post studies) (Tsai et al. 2009, Lin et al. 2001, 2002) that functional magnetic stimulation may reduce colonic transit time in individuals with SCI.

There is level 4 evidence (from one pre-post study with two subjects) (Mentes et al. 2007) that posterior tibial nerve stimulation improves bowel management for those with incomplete SCI.

There is level 4 evidence (from one pre-post study with two subjects) (Johnston et al. 2005) that the Praxis FES system increases the frequency of defecation and decreases time required for bowel care in individuals with SCI.

There is level 4 evidence (from one case series) (Puet et al. 1997) that supports using pulsed water irrigation (intermittent rapid pulses) to remove stool in individuals with SCI.

There is level 1b evidence (from one RCT) (Christensen et al. 2006) that supports the use of transanal irrigation (Peristeen Anal Irrigation system) over conservative bowel treatment (as outlined by the Paralyzed Veterans of America clinical practice guidelines) in individuals with chronic SCI and bowel management problems.

There is level 4 evidence (from one case series, one cross-sectional, and three non-randomized cohort studies) (Del Popolo et al 2008, Christensen et al 2008, Faaborg et al 2009, Kim et al 2013) that supports the use of transanal irrigation to manage neurogenic bowel dysfunction.

There is level 4 evidence (from four retrospective reviews) (Teichman et al. 1998; Christensen et al. 2000; Teichman et al. 2003, Worsoe et al. 2008) that the Malone Antegrade Continence Enema successfully treats neurogenic bowel dysfunction.

There is level 4 evidence (from one retrospective review) (Christensen et al. 2000) that the enema continence catheter can be used to treat neurogenic bowel dysfunction.

<u>Prucalopride</u>: There is level 1b evidence (from one RCT) (Krogh et al. 2002) that prucalopride increases stool frequency, improves stool consistency and decreases gastrointestinal GI transit time; higher doses (2mg/day) were associated with moderate/severe abdominal pain.

<u>Metoclopramide</u>: There is level 2 evidence (from one prospective controlled trial; N=20) (Segal et al. 1987) that intravenous administration of metoclopramide decreases time of gastric emptying.

Neostigmine: There is level 1b evidence (from one RCT) (Korsten et al. 2005) that neostigmine, administered with or without glycopyrrolate, leads to a greater expulsion of stool. There is level 1 evidence that neostigmine with glycopyrrolate decreases total bowel evacuation times and improves bowel evacuation.

<u>Fampridine</u>: There is level 1b evidence (from one RCT) (Cardenas et al. 2007) that fampridine can increase the number of days with bowel movements.

There is level 1b evidence (from 1 RCT) (House and Stiens 1997) to support polyethylene glycol-based suppositories for bowel management. There is a clinically significant decrease in the amount of nursing time for persons requiring assistance and less time performing bowel care for the independent individual.

There is level 4 evidence (from six studies) (Frisbie et al. 1986; Stone et al. 1990; Kelly et al. 1999; Rosito et al. 2002; Branagan et al. 2003, Munck et al. 2008) that colostomy reduces the number of hours spent on bowel care.

There is level 4 evidence (from one retrospective pre-post study) (Frisbie et al. 1986) that colostomy greatly simplifies bowel care routines.

There is level 4 evidence (from one case study) (Rosito et al. 2002) that colostomy reduces the number of hospitalizations caused by gastrointestinal problems and improves physical health, psychosocial adjustment and self-efficacy areas within quality of life.

There is level 4 evidence (from one cross-sectional study) (Coggrave et al. 2012) that colostomy reduces need for laxative use and dietary manipulation to assist bowel care.
There is level 5 evidence (from one case report with one subject) (Hoenig et al. 2001) that a standing table alleviates constipation in an individual with SCI.

There is level 4 evidence (from one cross-sectional study) (Uchikawa et al. 2007) that a newly developed washing toilet seat with a CCD camera monitor for visual feedback reduces time spent on bowel care.

7.0 References

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