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Interferential current therapy improved constipation and pelvic floor muscle activity in cerebral palsy children: A case series

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***Abstract*---**Background: Objective: The aim of this case report was to evaluate interferential current (IFC) therapy as adjuvant in treating constipation and abnormal pelvic floor muscle activity in cerebral palsy (CP) children. Study design: Nine CP children aged between 4,5 to 13 years old who had constipation according to ROME IV criteria received pre post test examination. At the baseline we collected data

regarding the Pediatric Incontinence and Constipation Score (PICS), Pediatric Quality of Life (PedsQL), and pelvic floor muscle activity at rest and during contraction. They received standard lactulose therapy and IFC therapy with a frequency of 4000-4100 Hz, duration 20 minutes, 3 times a week for 4 weeks. A week after the last IFC series, the parameters were re-evaluated to assess outcomes. Data were analyzed with SPSS v20.0. Results: PICS for constipation improved (P= 0,005), PedsQL improved at pain parameter (p = 0,008), and the pelvic floor muscle activity reduced significantly at rest (P= 0,036) in CP with constipation after received additional IFC therapy. Conclusion: IFC therapy as an addition to standard lactulose therapy can improved constipation and abnormal pelvic floor muscle activity, so that IFC can be an alternative supporting therapy in CP children with constipation to provide a good clinical response and no adverse effect.

***Keywords*---**Interferential Current, Constipation, Pelvic Floor Muscle, PICS, PedsQL

Introduction

Interferential phenomena by using two different current was introduced by Hans Nemec a *scientist* from Austria after World War II[1]. This concept about IFC macchiene was developed due to inconvenience using higher frequency of Transcutaneus Electrical Nerve Stimulation (TENS) to achieved deeper penetration[2]. Interference currents can depolarize peripheral nerve fibers through the application of electrodes placed on the surface of the treated area so that they affect motor and sensory nerve fibers[14]. IFC is effectively used for overactive bladder and urinary incontinence. After treating urinary incontinence with electrical stimulation often reported incidence of diarhea. Therefore, it is assumed that IFC can also be used to treat constipation[3,4]

Prevalence of chronic constipation in CP children affects between 26% to 74%[5]. Constipation is often not realized until months or years before appropriate treatment provided. Such delay because constipation is considered as an invetible consequence of the disability and higher priority in more urgent matters, such as seizures and postural deformities[6].

Cortical and subcortical disruption occured in children with CP that responsible in gastrointestinal disfunction including colon motility, gastrointestinal reflux, prolong of colonic transit time in proximal colon[7]. Spasticity in CP children can be exacerbated by abdominal pain due to muscle cramps and unsuccessful defecation that cause by chronic constipation and vice versa[8,9]. The pain and discomfort that follows chronic constipation can affect behavior and reduce quality of life[6]. Lactulose is reported to be effective and safe in children with chronic constipation[10]. However, lactulose is only temporary in relieving symptoms of constipation, and not effective for majority CP children [6,11].

Chase *et al* reported five of eight children who suffered from severe constipation increased frequency defecation after IFC therapy administered for 20-30 minutes per session and stopped soiling in seven of eight children, with therapeutic effects lasting more than three months in some children[12]. IFC and pelvic floor muscle exercise are used to treat constipation in children with functional constipation and improves median constipation score in PICS and improves pain in visual analogue scale (VAS)[13].

Prosser *et al* used sEMG to examine the activity of the pelvic and abdominal muscles in young children with and without spastic CP. The study showed that the average EMG frequency of all muscles assessed in spastic CP children have a significant increase[15.] This study examined the effect of IFC as an adjuvant of standard lactulose therapy for CP children with constipation.

Methods

This study was conducted at the Outpatient Clinic of the Medical Rehabilitation Installation of Dr. Soetomo Academic General Hospital Surabaya for 17 months, from February 2020 to July 2021. Written informed consent was obtained from all parents or guardians of the children who agreed to be research participants. The research has received a certificate of ethical feasibility from the Health Research Ethics Committee of RSUD Dr. Soetomo Surabaya Indonesia number 1813/KEPK/11/2020.

Study Design and Treatment

The data were taken twice before and after the treatment. Prior to initiating therapy, the research staff collected data on PICS, PedsQL, and pelvic floor muscle activity at rest and during contraction. Subjects received lactulose therapy and IFC therapy as intervention. The lactulose with the trademark LACONS in @ 60 mL bottles were prepared by the Pharmacy Installation of Dr. Soetomo Academic General Hospital Surabaya. Lactulose was administered by parents at a dose of 1-3 mL/kgBW/day orally, given 2x/day for six days. IFC therapy was given at the Medical Rehabilitation Clinic of Dr. Soetomo Academic General Hospital Surabaya. IFC therapy (ENDOMED 982) with carrier frequency 4000-4100 Hz, beat frequency 100 Hz, amplitude 1-50 mA, sweep mode was carried out by the researchers for 20 minutes, three times a week, with a total of 12 times therapy. One week after the last therapy, PICS, PedsQL, and pelvic floor muscle activity at rest and during contraction were re-evaluated. The side effects of lactulose and IFC therapy were managed according to the standard procedures at Dr. Soetomo Academic General Hospital Surabaya.

Table 1. Inclusion/Exclusion Criteria

Inclusion criteria	Exclusion criteria
1. Children aged 4 – 18 years old at the time of the study. 2. Diagnosed with CP by a pediatric neurologist consultant or a specialist in physical medicine and rehabilitation 3. Constipation symptoms according to ROME IV criteria. 4. Refrain from taking drugs that can cause constipation (muscle relaxants, antiemetics, antacids, antidiarrhea, antidepressants, antipsychotics, antispasmodics, analgesics, decongestants, iron supplements) at least 72 hours prior to treatment, except epilepsy, hypertension, and bronchodilator medication.	Patient with: 1. Congenital anatomic abnormalities, including Hisprung's disease, spina bifida, anorectal malformations, urethral strictures. 2. Down syndrome or hypothyroidism. 3. Gastrointestinal bleeding, intestinal perforation, ileus obstruction, inflammatory bowel disease, and toxic megacolon. 4. Metal implants or pacemakers in the abdominal area. 5. Open wounds in the abdominal and thoracic region. 6. History of surgery on the stomach 7. Malignancy. 8. History of allergy to lactulose and the electrodes used in this study.

Participants

Participants in this study were children aged 4-18 years, diagnosed CP with symptoms of constipation according to ROME IV[16,17] criteria, not taking drugs that can cause constipation and without any congenital anatomic abnormalities, and all conditions that contraindicate the therapy used in this study. The full inclusion/exclusion criteria are presented in Table 1.

Outcomes
Pediatric Incontinence and Constipation Score (PICS)

PICS is a questionnaire developed by Fichtner-Feigl et al in Germany in 2002 to assess constipation and fecal incontinence in children at one time. The incontinence assessment was obtained from the variables of the use of diapers during the day and night, and control of the desire to defecate. Assessment of constipation and incontinence from the variable frequency of defecation, stool shape, can distinguish feces from flatus, pain and straining during defecation. Constipation assessment was obtained from soiling variables, complete defecation, flatulence, and abdominal pain. The highest incontinence score was 32 (complete continence), score <23 (incontinence) and the total score for constipation was 29 (not constipated), the score was <20 (constipation)[18].

Quality of Life (PedsQL)

Quality of life assessment in CP children was carried out using the PedsQL™ questionnaire 3.0 version of the cerebral palsy module in Indonesian. This questionnaire was obtained from parents or caregivers reports by answering questions that often been a problem for children in the last 1 month. Parents were asked to circle 1 of 5 answer choices (5 point Likert scale). There are 7 categories, which are problems with daily activities, school activities, movement and balance, pain, fatigue, eating activities, speaking and communication[19].

Pelvic Floor Muscle Activity

Measurements were made using sEMG (MYOMED 632). Two active electrodes were placed on the levator ani muscle at 10 o'clock and 4 o'clock position. The results of measuring the value of pelvic floor muscle activity are expressed in the number of amplitudes with units of μV.

At Rest

The patient was instructed to rest/relax for 2 minutes.

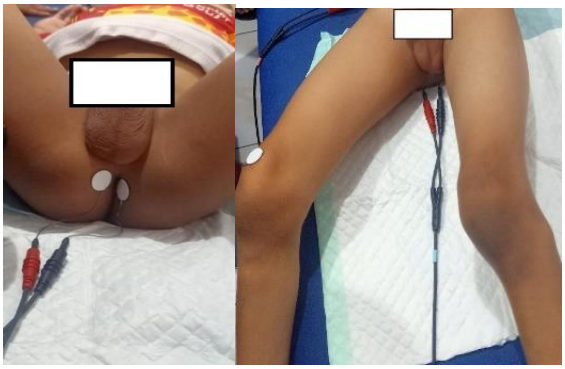

Figure 1. Placement of electrodes (sEMG) at the pelvic floor muscles and position of the subject

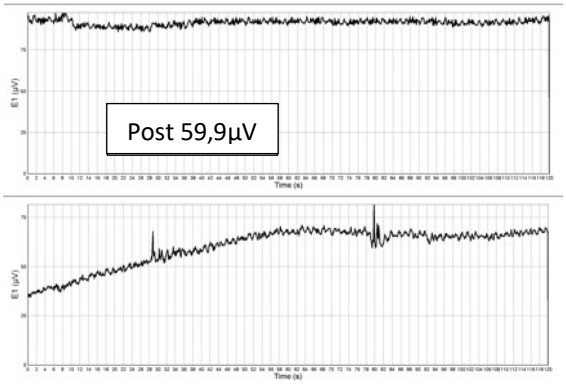

Figure 2. Pelvic floor muscle activity recording with sEMG at rest

During Contraction
The patient was instructed to contract pelvic floor muscle by clenching the butt cheeks together for 10 seconds followed by a relaxation period of 10 seconds, repeated up to 5 times in a row. Clenching butt check together will help keep the rectum muscles tense, but it is difficult to instruct for severe CP children.

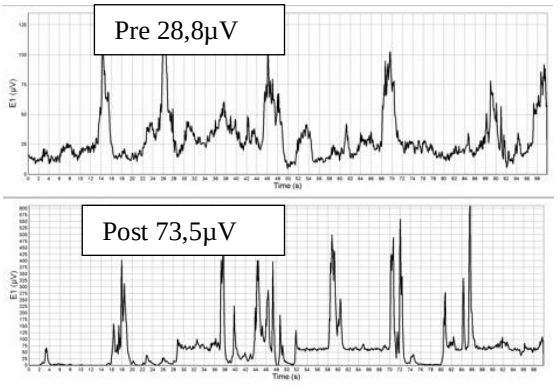

Figure 3. Pelvic floor muscle activity recording with sEMG during contraction

Statistical Analyses

The data collected were analyzed using SPSS v20.0. comparing the outcomes before and after treatment using the paired t-test. It is considered significant if $p < 0.05$.

Results

All the subjects can complete the study. At the end of the study, data on nine individuals were analyzed.

Table 2. Outcomes

	Treatment (n=9)		
	Pre	Post	*p-value*
PICS Constipation	9,89 ± 5,63	15,33 ± 5,76	0,005*
PICS Incontinens	16,44 ± 6, 01	15,33 ± 6,19	0,606
PedsQL pain parameter	45,83 ± 18,22	65,97 ± 22,12	0,008*
Pelvic Floor Muscle Activity during rest (µV)	32,18 ± 43,09	19,09 ± 30,14	0,036*
Pelvic Floor Muscle Activity during contraction (µV)	64,86 ± 137,28	38,72 ± 56,42	0,390

* Significant if p-value < 0.05

The mean of PICS Constipation increased significantly from 9,89 ± 5,63 to 15,33 ± 5,76 (p = 0,005). PedsQL improved significantly in pain parameter from 45,83 ± 18,22 to 65,97 ± 22,12 (p = 0,008). Pelvic floor muscle activity at rest before and after therapy showed a statistically significant decrease (p = 0.036) from 32,18 ± 43,09 µV before treatment and 19,09 ± 30,14 µV after treatment. There was no

significant improvement in PICS incontinence and pelvic floor muscle activity during contraction with p > 0,05.

Discussion

The Pediatric Incontinence and Constipation Score for constipation had statistically significant improvement in the treatment group (p = 0.005). The results of this study are in line with the study conducted by Sharifi-Rad *et al.*, 90 children aged 5-13 years with functional constipation who received pelvic floor muscle (PFM) exercise and IFC therapy were compared with those who received PFM exercise and sham IFC therapy. IFC therapy was given for 10 sessions, 2 times a week, 20 minutes per session, carrier frequency 4 kHz, beat frequency 5-25 Hz, duration 250 microseconds, intensity 0-50 mA. The median score of PICS for constipation (0-29) and pain with a visual analogue scale (VAS 0-10) showed significant improvements with p = 0.000 and p = 0.03[13]. This is in accordance with previous research by Chase *et al.*, which provides IFC 3-4 weeks in children with chronic constipation reported an increase in the frequency of defecation in 5 of 8 children and 7 of 8 children stopped soiling with a therapeutic effect lasting up to 3 months in 3 children[12].

Sacral reflex modulation occurs when the differential stimulation technique is used to improve bowel control[20]. The colon is activated by parasympathetic innervation via the vagus and pelvic nerves originating from the sacral segments S2-S4[21]. To facilitate defecation, the parasympathetic innervation transports motor nerves to the colon, rectum, and relaxation of the internal anal sphincter, followed by the external anal sphincter and puborectalis[22]. Stimulus are applied on surface electrodes to T9–L2, which is a sympathetic flow. The enteric nervous system, located in the myenteric plexus or submucosa, sends signals to the gastrointestinal tract's muscle layer, causing the neurotransmitter serotonin 5-hydroxytryptamine to be released[23,24].

Interstitial pacemaker, also known as Cajal cells, are critical for the normal movement of the colon and mediate the transmission of signals from nerves to muscles[25]. The effect of IFC appears increase gradually and clearly persists for months after therapy is stopped. It showed that the cellular system, which includes Cajal cells, is expanding[26]. The effects of IFC can last up to one month in five out of six children and three months in three out of six children[12]. Kajbafzadeh *et al.* reported IFC in myelomeningocele patients with constipation who had failed conventional therapies such as diet modification and laxatives resulted in 73% of symptoms diminishing immediately after IFC and 53% of the effect lasting up to 6 months[20]. IFC was also able to improve quality of life[27].

Pelvic floor muscle activity at rest before therapy was shown above the baseline value with an average of 32,18 ± 43,09 μV. A complete noise-free recording is impossible. Small amplitude spikes or random nature may be visible, but they should not exceed 10 – 15 microvolts[28].

In children with CP, muscle hypertonia and hypotonia are reported as common disorders that contribute to varying degrees of motor dysfunction[29]. Although at the beginning of the study there was no specific MAS examination of the pelvic

floor muscles, it can be seen from the high amplitude on the initial sEMG that the muscle was experiencing spasticity. This is in line with the study by Logosu *et al* in 15 children with spastic CP aged between 1 and 10 years who were given 100 Hz electrical stimulation (TENS) therapy for 30 minutes on the ankle dorsiflexion muscle which resulted in a significant decrease in MAS and an increase in range of motion ($p = 0.038$). TENS can reduce spasticity in CP by reducing neuronal excitability[30] and decreasing stretch reflex sensitivity[31]. A significant increase in muscle activity at rest in individuals with spastic CP indicates the occurrence of hypertonia[29,32]. These measurements recorded during the resting phase could be due to increased motor neuron activity and uninhibited activity of motor neurons in this muscle[32].

An EMG of the anal sphincter can confirm appropriate muscle contraction during clamping and relaxation at rest. In people with paradoxical sphincter and pelvic floor muscle contraction disorders, muscle activity will increase and not decrease during straining to stimulate defecation. SEMG placed perianally can identify pelvic floor muscle dysfunction associated with constipation[34]. In this study, a significant decrease in pelvic floor muscle activity was found at rest after being given therapy ($p=0.036$). These measurements recorded during the resting phase could be due to increased motor neuron activity and uninhibited activity of motor neurons in this muscle[32]. IFC generates a 100 Hz interference wave between two medium frequency currents across the skin surface which is associated with less skin resistance so that the IFC can penetrate deep tissue effectively and stimulate muscles directly thereby further reducing tone[33,35,39].

Inhibitory neurotransmitters such as gamma-aminobutyric acid (GABA) and opioid agonists can exert anti-spastic effects by inducing inhibitory neurotransmitters at presynaptic terminals[36]. High-frequency electrical stimulation (100Hz) isolates gamma-aminobutyric acid from the dorsal horn of the spinal cord and decreases muscle tone by increasing presynaptic inhibition[33,37]. Interventions that produce a resultant beat frequency of 100 Hz into the tissue are expected to increase levels of endogenous inhibitory neurotransmitters and can cause effects similar to anti-spastic drugs[35].

Motor stimulation of muscles will occur if given IFC current with a frequency between 1-100 Hz. At low frequencies produce twitch contractions, frequencies of 5-20 Hz produce partial tetanic contractions, and frequencies of 30-100 Hz produce tetanic contractions (Forster et al., 1985). The frequency used in this study is 80-100 Hz so that it can modulate the pelvic floor muscles. Muscles contract due to electrical stimulation into the muscle so that it is analogous to voluntary contraction. An increase in local circulation produced by the local pumping effect of stimulated muscles or the effects of autonomic nerves and blood vessels can help remove chemicals that stimulate nociceptors so as to reduce pain[38]. In steady or repetitive voluntary contractions (slow twitch), the muscle fibers that are fatigue resistant will be recruited first and produce lower peak forces with longer duration. Fast twitch muscle fibers produce high peak forces with short duration and are recruited last so that their energy is not efficient, but these fibers will be recruited first on muscle electrical stimulation and a few motor units will fire at high frequencies. This recruitment of fatigued muscle fibers results in an enormous but untenable increase in muscle strength.

Fatigue usually does not occur with voluntary contraction but may occur with transcutaneous stimulation because of the higher frequency activation. The fatigue-resistant and energy-efficient motor units are recruited first while the fatigued and fast-twitch muscle fibers are stored in reserve for shorter duration and higher strength. In electrically induced contractions, there is an unequal recruitment of large-diameter muscle fibers that tire quickly with the rate at which fatigue develops[40,41,42]. Contraction of the rectus abdominus muscle plays a role in increasing intra-abdominal pressure along with contraction of the pelvic floor muscles, diaphragm, closure of the glottis and rectum during expulsion of feces through the anus[43].

Conclusions

This study indicates given IFC therapy as adjuvant to standard constipation therapy can improved clinical response and there are no adverse effects. Implying that IFC can be used as supportive therapy in CP with constipation. Suggestions for future research include the need to monitor the effects of IFC over a longer period to ascertain their resilience.

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