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DIAGNOSTIC BLOCKS OF THE TIBIAL NERVE IN SPASTIC HEMIPARESIS

Effects on Clinical, Electrophysiological and Gait Parameters

J. H. Arendzen,[1] H. van Duijn,[2] M. K. F. Beckmann,[2] J. Harlaar,[3]
T. W. Vogelaar[3] and A. J. H. Prevo[3]

From the [1]Department of Rehabilitation University Hospital Groningen, The Netherlands and the Departments of [2]Clinical Neurophysiology and [3]Rehabilitation, Free University Hospital Amsterdam, The Netherlands

ABSTRACT. The value of a diagnostic block (DB) of the tibial nerve in 17 hemiparetic patients with gait disturbances was investigated. The purpose of this study was to find instruments that help to select patients who will benefit from a long lasting peripheral nerve block. The manually elicited ankle clonus and its abolition after injection of a local anaesthetic appeared to be a useful clinical test for the efficacy of DB. Electrophysiological tests proved valuable when DB failed to produce clinical effects. With a substantial number of blocked nerve fibres walking velocity did not deteriorate. Transient disturbances in sensation can be regarded as unwanted side effects that might adversely affect the walking ability. From the different aspects of gait an improved heelcontact demonstrated the functional gain in patients with a dynamic equinus foot. To differentiate between a dynamic equinus foot and fixed contractures, we recommend the use of a fast acting local anaesthetic for diagnostic nerve blocks.

Key words: hemiplegia, spasticity, peripheral nerve block, electrophysiology, gait.

Spasticity, defined as a velocity dependent stretch response (17), is often held responsible for a disturbed walking ability. Drug therapies, surgical procedures (rhizotomies and neurectomies) or nerve blocks can effectively reduce hyperreflexia and resistance to passive stretch. Young et al. (29) stated, however, that this reduction does not necessarily imply an improved function. This is mainly due to the complex nature of disintegration of the Central Nervous System which is also manifest in other symptoms like e.g. paresis, co-contractions, loss of dexterity, and viscoelastic changes in affected muscles (8, 16).

The application of local anaesthetics to motor nerve fibres has been subject of investigation both in animal experiments (18, 23) and studies in man (8, 27). These studies demonstrate a preferential blocking of gamma efferents by weak (0.2%) procaine solutions which cause an extinction of the stretch reflex and the tendon jerk but without impairment of voluntary movement. These results have led to the common belief in an increased gamma-motoneuron discharge in spastic patients and to the clinical differentiation between alpha- and gamma-spasticity. By means of microelectrodes, Hagbarth et al. (9) and Burke et al. (5) were able to demonstrate that absence of fusimotor drive did not necessarily imply a decreased spindle sensitivity in some spastic patients. A central hypersensitivity to afferent (proprioceptive and cutaneous) inflow is thought to be responsible for the exaggerated dynamic stretch reflexes in patients with lesions of the cerebro-spinal pathways (5, 8). Reports on peripheral nerve blocks by percutaneously applied local anaesthetics as a diagnostic tool prior to longer lasting therapies are scanty and do not cover systematical investigations (4, 13, 15, 22, 26).

The purpose of this study was to look for discriminative parameters that could help to distinguish between patients that may or may not benefit from a non-selective tibial nerve block. In a prospective clinical trial we compared clinical, electrophysiological and walking parameters before and after an injection of bupivacain (0.5%) into the tibial nerve of patients with a spastic hemiparesis. The present study is part of a comprehensive research project into the efficacy of peripheral nerve blocks by means of radiofrequency (RF) heat lesions in the management of spasticity (1).

METHODS

Seventeen hemiplegic patients whose medical data are listed in Table I were selected for a diagnostic block (DB) of the tibial nerve in the spastic leg on the following criteria:

Table I. *Patients medical data*

Patient	Age (y)	Sex	L/R	CVA (y)
1	49	F	L	14
2	58	M	R	3
3	47	M	L	5
4	68	F	L	2
5	65	M	L	9
6	44	M	L	1
7	42	F	L	5
8	55	F	L	5
9	53	M	R	3
10	58	M	R	3
11	65	F	L	19
12	70	F	L	1
13	50	F	L	9
14	57	M	L	2
15	69	M	R	1
16	65	M	R	2
17	49	M	L	1

(1) an acquired spastic hemiparesis after a cerebrovascular accident (CVA),
(2) a stable neurologic condition, at least 1 year after the CVA,
(3) hyperreflexia cq ankle clonus, and/or
(4) equinus position of the foot at the initial or total stance phase.

Not allowed were:

(5) antispasmodic medication,
(6) previous tibial nerve blocks,
(7) functional electrostimulation during the last three months.

The mean age of the selected patients was 56.7 years (range 42–70) with an average of 7.6 years (range 1–19) after the CVA. In 12 cases there was a left sided hemiparesis and the male/female ratio was 10/7. After a written informed consent was obtained all patients underwent a series of assessments in order to collect clinical, electrophysiological and gait parameters. Thereafter a DB was applied.

Thirty minutes after completing this procedure the examinations were repeated in the same sequence as before the nerve block.

Clinical parameters

Neurologic examination included special attention to:

(a) Sensory testing of touch and proprioceptive qualities of the foot.

Score included 0 = equal to non-affected side (NAS), 1 = slightly less to NAS, 2 = little perception, and 3 = no perception.

(b) Alternate involuntary muscle contraction and relaxation in rapid succession upon a sudden stretch of the triceps surae (ankle clonus).

To quantify the ankle clonus the patient was seated in an upright position with hip and knee 90° flexed. The foot was hanging free and electromyographic (EMG) activity was recorded from gastrocnemius muscles with bipolar surface electrodes. Repetition rate was scored according to Touwen (1979): 0 = no contraction, 1 = 2–4 contractions, 2 = 5–7 contractions, 3 = 8 or more contractions.

Electrophysiological parameters

For reflex studies of both legs the patients were comfortably positioned, prone on the examination table, the knees slightly flexed and feet hanging free for maximal relaxation. The tibial nerve was stimulated at the popliteal fossa with a bipolar surface stimulator (fixed pole distance = 2 cm, stimulus duration 1.0 msec, rate 1 Hz). Compound action potentials were recorded from the soleus muscle with a pair of longitudinally placed surface electrodes (interelectrode distance = 4 cm) at approximately 2/3 of the distance from distal stimulation point and the flare of the medial malleolus. The distance between distal stimulation point and proximal recording electrode was kept constant. After DB the point of stimulation was the same as before and at the site of the nerve block. Recordings were amplified and stored on an oscilloscope (Medelec MS8). Maximal responses were printed on visicorder paper (Kodak™) för further analysis.

The following parameters were studied:

A. Maximal amplitude of the Hoffmann reflex (H-REFLEX) in mV,
B. Amplitude of the compound action potential to supramaximal stimulation (M-RESPONSE) in mV,
C. Interval between H-REFLEX and M-RESPONSE (H-M int) in msec,
D. From A and B the H/M ratio was calculated,
E. After 10 successive beats on the Achilles tendon with a handhold electrically triggered reflex hammer the maximal amplitude of the Achilles tendon reflex (ATR) was measured in mV,
F. The latency between trigger and action potential (ATR-lat) in msec, and
G. Skin temperature of the mid-plantar surface of both feet in centigrade.

Gait parameters

Locomotion was analyzed on a 10 meter level walking course. Infrared gate switches bordered a central 5.5 meter recording section. Flexible soles with built-in contact switches were attached to the patients bare feet with Velcro strips. The four switches are weight dependent (treshold = ± 100 g/cm^2; variation 20%) and signals from heel, fifth metatarsal, first metatarsal and toe contact can be identified for analyzing the foot support pattern (Fig. 1). From both legs footswitch signals were led to a junction box attached to a waist belt carried by the patient. A multichannel lightweight cable connected the junction box to the footswitch decoder. All analog signals were simultaneously recorded on line on an x-t recorder (Siemens). After A-D conversion (ADC 16-20-2 kTNR, Digilog) the digital signals were read by a microcomputer with a sample frequency of 120 Hz. For reasons of memory saving data averaging (symmetric triangle-window) gave a net sample frequency of 60 Hz and this was stored on floppy disk.

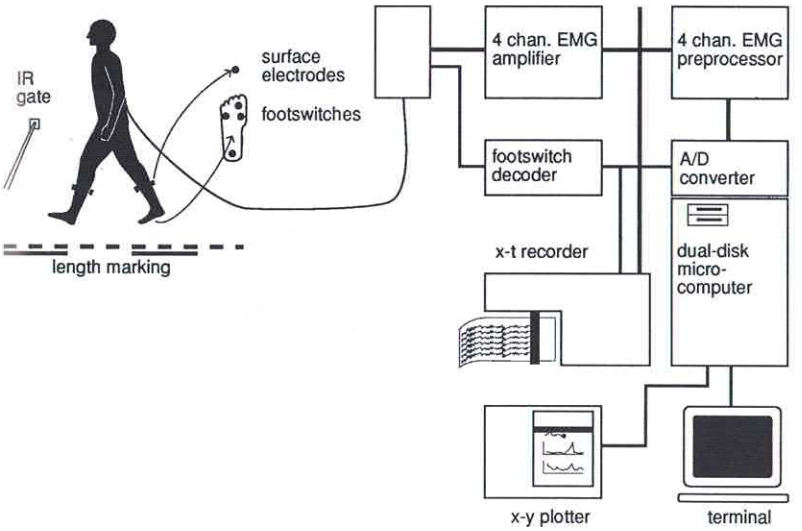

Fig. 1. Outline of walking course and data recording (see text for detailed explanation).

Foot contact-time of the affected (A) limb was distinguished from foot contact-time of the contralateral (C) limb.

The patient was asked to walk the length of the walkway as fast as possible with the customary walking aid but without ankle-foot orthosis and manual assist was given if necessary. The measuring-sessions consisted of six runs and after each run two minutes of rest were allowed. Results from each run, which had to include a minimum of 3 strides within 20 sec, were averaged resulting in the following gait parameters:

(a) walking velocity in meters per second (m/sec),
(b) stride-time in seconds,
(c) cadence in steps per minute (st/min),
(d) stance-time C in seconds,
(e) swing-time C in seconds,
(f) stance-time A in seconds,
(g) swing-time A in seconds,
(h) double stance-time A–C in seconds,
(i) double stance-time C–A in seconds,
(j) step-time A–C in seconds, and
(k) step-time C–A in seconds.

Besides the measured stance- and swing-times the relative time per gait cycle was calculated as a percentage of stride-time (%) and some symmetry factors were observed:

(l) heelcontact-time C in %,
(m) heelcontact-time A in %,
(n) swing-time C and A in %,
(o) stance-time A and C in %,
(p) double stance-time CA and AC in %,
(q) step-time A/C in %,
(r) stance-time A/stance-time C,
(s) swing-time C/swing-time A,
(t) double stance AC/double stance CA, and
(u) step-time AC/step-time CA.

Results from three (the best out of six) runs per session before and after DB were averaged and standard deviations calculated.

In order to test the validity of the measuring-instrument gait parameters of six healthy volunteers and three hemiplegics were obtained from six different sessions.

Statistics

Clinical parameters before and after DB will be described and compared individually. Results from electrophysiologic tests include individual values, the mean, median and standard deviations (SD) for the distinguished parameters. The results obtained before and after DB have been submitted to statistic analysis by using a paired Student-*t* test with a confidence-interval of 99 %. From the gait parameters the mean, standard deviation, variation and the average percentage of the gait cycle before and after DB have been observed. A non-parametric test (Wilcoxon) with a confidence-interval of 99 % was used for statistic analysis.

Diagnostic block of the tibial nerve

With the patient in a prone position on the examination table the tibial nerve at the popliteal fold was localized with an electrical nerve stimulator (Neutracer Top™, rectangular wave: 2 msec, 0.5 Hz). The skin was marked where the lowest voltage provoked a twitch. After iodizing and anaesthetization of the skin a 23 gauge 50 mm, teflon coated, pole needle was inserted and connected to the nerve stimulator. The moment of penetration of the nerve became clear from the sudden fall of the stimulation threshold after which the local anaesthetic could be injected. This was done in a stepwise manner. After muscle twitches were obtained at the lowest possible stimulation threshold a small amount (0.1 ml) of 0.5 % bupivacain was slowly injected whereupon the muscle responses stopped. Thereafter the stimulation threshold was increased until muscle twitches reappeared and again 0.1 ml of the local anaesthetic was injected.

This procedure was repeated several times with the needle directed in slightly different directions. When muscle contractions stayed away at maximal capacity of the stimulator DB was considered to be completed. The minimal amount of

Table II. *Clinical results before and after DB*

Sensory functions were tested for touch (t) and proprioception (p)

Patient	Sensory functions t/p before	Sensory functions t/p after	Clonus Before	Clonus After
1[a]	1/2	1/2	3	3[c]
2	1/1	2/2	3	0
3	0/0	1/1	3	0
4[a]	2/2	2/2	3	2[c]
5	0/1	1/1	3	0
6	0/0	2/2	3	0
7	1/1	1/1	3	0
8[a]	2/2	2/2	3	3[c]
9[a]	1/1	1/1	0[c]	0
10	0/0	1/1	3	0
11[a]	1/1	1/1	3	3[c]
12	0/0	0/0	3	0
13	0/0	0/0	2	0
14	0/0	0/0	3	1
15	0/0	2/2	0[c]	0
16	0/1	0/1	1	0
17	0/1	2/2	3	0

[a] Patients with no changes after DB.
[b] Reduced sensory functions.
[c] Unaltered ankle clonus.

the injected anaesthetic solution was 1 ml and the maximal amount did not exceed 3 ml. After 30 min the clinical, electrophysiological and gait analyses were executed in the same sequence as before the DB. A 0.5% bupivacain solution was chosen because its 7–12 hours effect would enable the patients to experience the possible benefits of the reduced hyperreflexia.

RESULTS

Clinical parameters

Because of the short-term effects of the local anaesthetic no alterations were expected in the walking ability on the days following the DB. Nevertheless 3 patients reported an improvement lasting for up to 4 days, where the hindering clonus had disappeared and they were able to walk indoors without their usual walking aids. On the other hand in one patient (no. 15) the walking performance deteriorated for more than 24 hours due to sensory loss.

Before DB sensory functions for touch and proprioceptive qualities were normal or slightly lowered in all but 2 patients (nos. 04 and 08) who had little perception at the affected side. In 7 patients (7/15) DB affected sensibility; a marked reduction (grade 2) was seen in four patients and a slight loss (grade 1) in three. In 13 patients an ankle clonus was easily elicited and continued for more than 8 consecutive contractions (grade 3). Two had lower grades (2 and 1) and in 2 patients an ankle clonus could not be detected in the standardized position. After injection of the anaesthetic the clonus had disappeared (grade 0) in 10 (10/15) patients, was partially reduced in 2 and unaffected in 3 cases (Table II).

Electrophysiological parameters

Before treatment mean amplitudes of the H-REFLEX were larger in the affected limb (mean 9.1 mV; SD ± 5.1; range 0.6–17.5 mV) than at the contralateral side (mean 6.8 mV; SD ± 4.4; range 0.8–14 mV) ($n=17$, $p<0.005$).

The M-RESPONSE was slightly smaller on the hemiparetic side (mean 15.1 mV; SD ± 7.2; range 2.2–34 mV) than in the contralateral leg (mean 16.3 mV; SD ± 5.0; range 8.5–28 mV) (not signif.) The mechanically evoked ATR had a higher amplitude in the spastic limb (mean 7.9 mV; SD ± 4.3; range 0.8–15 mV) when compared to the unaffected side (mean 5.3 mV; SD ± 3.8; range 0.1–11 mV) ($p<0.001$).

After DB an average reduction of the H-REFLEX of 53% was found ($p<0.005$). Furthermore an average decrease of the M-RESPONSE amplitudes of 37% was measured in this group of patients ($p<0.01$). As a result the H/M ratio on the affected side decreased from an average of 0.58 (SD ± 0.20) to 0.33 (SD ± 0.27) ($p<0.005$); the H/M ratios on the non-affected side changed from an average of 0.42 (SD ± 0.25) before to 0.46 (SD ± 0.24) after the procedure (not-significant).

An average reduction of 57% in the amplitudes of the ATR was found ($p<0.005$). The mean of H-REFLEX, M-RESPONSE, and ATR amplitudes of both legs before (M 1) and after diagnostic block (M 2) are graphically represented in Fig. 2.

In 6 (6/17) patients a tendon jerk could not be elicited any more after the DB. In those patients where a tendon jerk had remained, besides a marked reduction in amplitudes, a slight but significant delay in the latency for the ATR was observed ($p<0.05$, Wilcoxon Rank test). No significant changes were seen in the H-M interval after the DB.

From the mid-plantar surface of the treated leg we measured an average temperature rise of 4.2°C ($p<0.01$) whereas the temperature of the control side remained almost unchanged (29.4°C before and 29.1°C after DB).

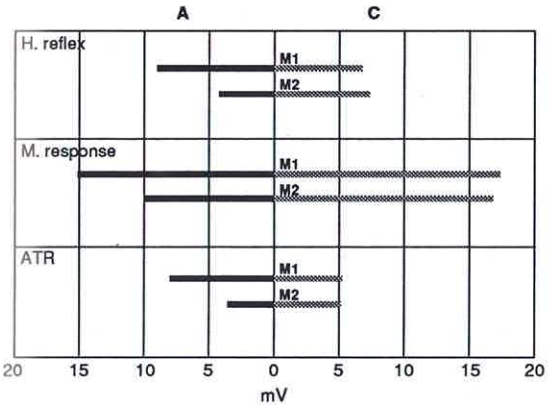

Fig. 2. Results of electrophysiological tests in millivolts (mV) before (M1) and after diagnostic blocks (M2). From the affected leg (A) and the contralateral side (C) the mean values are graphically represented.

Gait parametes

The average comfortable walking velocity of six healthy volunteers was 1.3 m/sec (SD ± 0.14) over 36 runs and there appeared to be a considerable spread (range 3.3–7.8 %) in the intra-individual results of six different sessions. Nevertheless the individual spread of temporal parameters like stance- and swing-time were less than 5 %. Parameters with a relatively short contact-time during the gait cycle, like double stance- and heel contact-time, showed a greater variation, probably due to the used sample frequency of 60 Hz, and were thus less reliable. However, this problem does not occur in the slow walking velocity of hemiparetic patients under investigation.

Except for one patient (06), maximal walking velocity remained unchanged (07, 09) or showed a small increase after DB. An average of 0.21 m sec^{-1} (SD ± 0.15) was recorded before treatment and 0.26 m sec^{-1} (SD ± 0.18) after treatment which means a small but statistically significant improvement in the speed of walking ($p < 0.01$). This was in accordance with slightly (not significant) reduced stride-times. Only small and insignificant changes were measured in the average stance-time (A) of the affected limb as well as in the swing-time (C) of the contralateral leg. Both were expressed as a percentage of the stride time and showed 2 and 0 % improvement respectively. Individual changes in double stance- and step-time of the affected leg were observed, but on the average these parameters did not alter significantly in the group under investigation.

The most remarkable change in the gait pattern was the reduction of the equinus position of the foot during stance. Heel contact, expressed as a percentage of the stride-time, showed an increase from 20 % (SD ± 19) to 28 % (SD ± 20) ($p < 0.01$). On the contralateral side no significant changes were seen (68 % before and 65 % after DB). Before DB the initial floor contact was made with the heel in 3 patients and after treatment 11 were able to make a heelstrike.

DISCUSSION

The present investigation was set up to find an instrument for selecting patients, with a spastic hemiparesis, that might benefit from a longer lasting tibial nerve block. The study is part of a research program into the therapeutic effect of radiofrequency heat lesions of peripheral nerves (1). To evaluate the effects of DB clinical, electrophysiological and gait parameters were studied.

The value of a locally injected anaesthetic has been mentioned by some authors (4, 12, 22, 26), but the magnitude of the alterations were not thoroughly documented. Most studies dealing with phenol nerve blocks gave evidence of reduced spasticity (6, 11, 12, 13, 14, 21, 22, 24, 25) but the benefits for the patients were often summarized as: (*a*) improved performance of every day task (6, 12, 14), (*b*) facilitated ambulation (3, 12, 22, 24) and (*c*) alleviation of painful spastic conditions (22). Only Brattström et al. (3) studied electrophysiological variables 10 to 20 min after 2 % phenol injection into the tibial nerve. They found an average reduction of 70 % of the H-REFLEX amplitude and a more than 80 % decrease of the mechanically evoked ATR amplitude.

From our results we learned that after an injection of 0.5 % bupivacain the average reduction of the ATR amplitude did not exceed 57 %. An almost identical reduction in H-REFLEX (53 %) was found while the M-RESPONSE was only 37 % smaller after DB. No relation was seen between a facilitated ankle clonus and the amplitude of the compound action potentials. This was demonstrated in 2 patients (09 and 15) with relatively high amplitudes of the H-REFLEX and ATR before DB but without an ankle clonus in the standardized sitting position. There is strong evidence that in 5 patients (01, 04, 08, 09, 11) the nerve block had not produced any changes at all because electrophysiological results and the clonus remained unaltered. With the exclusion of these 5 patients the average reduction of the H-REFLEX, ATR and M-RESPONSE became 77 %, 83 % and 51 %, respective-

ly, and this is in accordance with the results of Brattström et al. (3).

Although the reflexes were more reduced than the electrically elicited maximal motor responses the design of the study does not allow any conclusions about the selectivity of the nerve block. A quantitative reduction in the number of normally transmitting fibers, both afferent and efferent, is probably responsible for the effects.

We tried to understand why in 5 out of 17 patients an effective nerve block failed to appear. When the drug is not properly applied intraneurally it takes more time to become effective, much more than the 30 min that were allowed in our study. At least 3 out of 5 patients which did not show an initial response (04, 08, 09) reported subjective changes several hours after the treatment. The same delay in response was probably the reason why in 2 patients (03 and 06) hardly any changes were found in the H-REFLEX and M-RESPONSE, but as time and sequence of examinations progressed the ATR became lower, the foot temperature readouts indicated a substantial block and in the case of patient 06 walking ability worsened progressively due to loss of sensation and limb weakness.

After treatment sensation had deteriorated from a normal to a markedly reduced level in 3 patients (03, 06, 15). In at least 2 (06, 15) this might have adversely intervened with their functional results. From phenol nerve blocks it is reported that they do not affect sensation significantly (6, 11, 12, 21, 25).

Another interesting phenomenon we recorded was the duration of effect in some patients. For example patient 05 reported to be relieved of severe spontaneous clonus for at least 3 days. Another patient (15) felt very unstable on the treated leg for more than 24 hours. This cannot be explained by the approximately 12 hours of effectiveness of the used drug but is probably due to the sustained changes in spinal excitability.

From the temporal gait parameters we tried to get an answer to the question which patients actually did improve their walking ability. Several studies (2, 10, 20, 28) reported the value of walking speed as a prime indicator for improvement of gait in hemiplegics. In our experiments we found a small but significant increase in velocity of gait. This is remarkable because a substantial number of fibers were blocked and must have increased the paresis of the calf muscles. Double stance-, step-, stance- and swing-time ratios did not show a functional gain.

It became clear that the heel contact parameter was the best indicator for improvement of function. Inadequate weight acceptance with the affected foot was markedly improved after DB. The often associated knee hyperextension during initial and midstance (16) had apparently disappeared in some patients but we lack a quantitative score.

The subjective remarks by some patients that standing and walking 'feels more relaxed' can be attributed to the improved ability of plantigrade locomotion. Subsequently, it might offer the patients an opportunity to omit their walking aids and improve their performance of daily activities.

Two patients (13 and 16) had initially low and very low responses to electrically and mechanically elicited reflexes and after DB a successful block was clearly demonstrated, but the equinus position was not influenced essentially because of a fixed contracture at the ankle.

We have to stress that motor disturbances in this group of hemiplegics were varying to some degree and that individual responses to the DB varied too.

CONCLUSION

A DB is a simple and safe procedure. It can be helpful in the selection of hemiplegic patients with gait disturbances who will benefit from a peripheral nerve block. The reduced hyperreflexia together with the improved plantigrade locomotion and a small increase in maximal walking velocity prove the value of the tibial nerve block in most of them. A fixed contracture at the ankle is easily distinguished from a dynamic equinus foot and appears to be a contraindication for a long lasting nerve block.

Electrophysiological tests help to discriminate between successful and abortive blocks. Because of the relatively high number of improper applied nerve blocks we recommend the use of a fast acting local anaesthetic for performing DB. Thus the effects can be evaluated shortly after finishing the procedure which can be repeated if necessary.

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Address for offprints:

J. H. Arendzen MD, PhD
Department of Rehabilitation
University Hospital
Oostersingel 59
9713 EZ Groningen
The Netherlands