# Modeling of Neuropathic Bladder Lesions Diagnosis Using Neural Network Algorithm.

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## Abstract:

*The urinary bladder is probably the only visceral smooth-muscle organ that is under complete voluntary control from the cerebral cortex. Normal bladder function requires interaction of sensory and motor components of both the somatic and autonomic nervous system. Recent advances in the understanding of neural pathways and neurotransmitters have shown that most levels of the nervous system are involved in the regulation of voiding function. Therefore many neuralgic diseases causes changes in the bladder function [1].*

*In this paper, Number of patients selected from Ibn-Alkiff hospital (for treatment and rehabilitation of Spinal cord injuries), in Baghdad, who were referred to the urology department for complains of some urinary symptoms, and examined by cystometry in the urology out patient and/or inpatient department.*

*These cases were selected randomly who already consult these departments and were followed up and managed by the expert urosurgeons. They were adults complaining of general neuropathic bladder disorder symptoms like frequency, urgency, dysuria, urinary incontinence and were diagnosed as having neuropathic bladder disease, whether:*

1. *Upper motor neuropathic bladder lesions.*
2. *Lower motor neuropathic bladder lesions.*

*And finally they were examined by cystometry.*
*The collections of data from patients were about:*

1. *Accommodation (compliance).*
2. *Bladder capacity.*
3. *Contractility.*
4. *Sensation.*
5. *Voluntary control.*

*These data with the final definition diagnosis about the neuropathic bladder lesion were processed to 3- layers Neural Network algorithm that was constructed in a matlab computer package.*

*Consequently after all data processing, the neural network model was tested by its capability of processing an already diagnosed neuropathic bladder case and its accuracy in explaining the real neurological bladder behavior of that selected patient.*

## 1. Artificial neural network:

The artificial neural network (ANN) attempts to imitate the learning activities of the human brain. The human brain is composed of approximately 10" neurons (nerve cells) of different types. In atypical neuron, one can find the nucleus, where the connections with other neurons are made through a network of fibers called dendrites. Extending out from the nucleus is the axon, which transmits, by means of a complex of chemical processes, electrical potentials to the neurons with which the axon is connected to ( Fig. 1)[2]. When the signals received by the neuron equal or surpass their threshold, it triggers sending the axon an electrical signal of constant level and duration. In this way, the message is transferred from one neuron to the other.

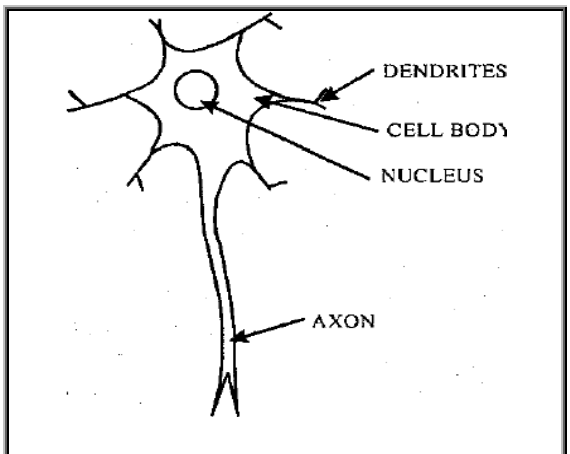


**Figure (1)** Typical biological neuron

In an ANN, the artificial neuron or the processing unit may have several input paths corresponding to the dendrites. The units combined usually by a simple summation of the weighted values of these paths (Fig. 2).

The weighted value is passed on to the neuron, where it is modified by the threshold function, such as sigmoid function (Fig. 3)[3].

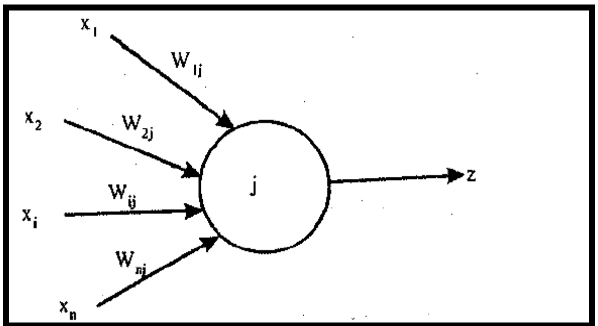


**Figure 2. Single processing unit**

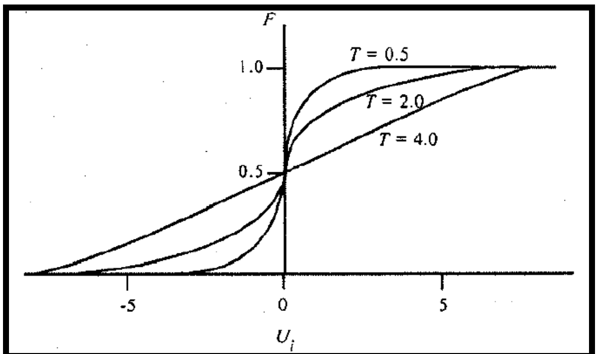


**Figure 3. Sigmoid function**

The Modified value is directly presented to the next neuron. In Fig. 4, a 3- 4- 2 feed- forward back propagation ANN is shown. The connections between the various neurons are strengthened or weakened according to the experiences obtained during the training. The algorithm for training of the back propagation neural network is explained in the following steps[4]:

Step 1. Select the number of hidden layers, number of iterations, tolerance of the mean square error, and initialize the weights and bias functions.

Step 2. Present the normalized input- output pattern sets to the neural network. At each node of the neural network except the nodes on the input layer, calculate the weighted sum of the input, add bias and apply sigmoid function.

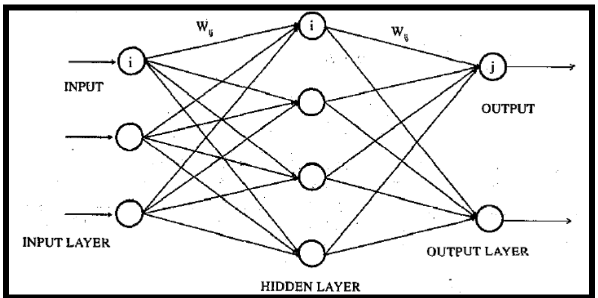


**Figure 4. Neural network**

Step 3. Calculate total mean error. If error is less than the permissible limit, the training process is stopped. Otherwise,
Step 4. Change the weights and bias values based on generalized delta rule and repeat step 2. The mathematical formulations of training the neural network have been given by Hertz and Krogh 9.

***3. CYSTOMETRY (BLADDER TEST):***

Cystometry is a test that measures the pressure inside of the bladder (Fig.5) to see how well the bladder is working. Cystometry is done when a muscle or nerve problem may be causing problems with how well the bladder holds or releases urine[5].

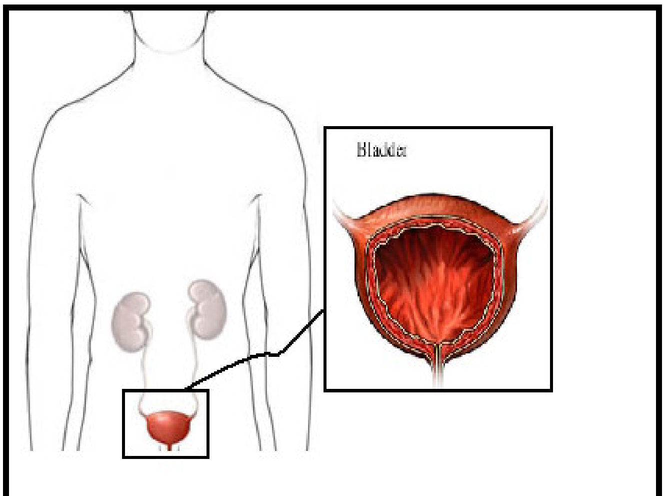

**Figure 5. Bladder position in the human pelvis**

Urination is a complex process. As the bladder fills, nerves in the bladder wall send a message to the spinal cord and brain that people need to urinate. In response, people spinal cord sends a signal to the urinary bladder to contract (voiding reflex). When he holds in his urine, his brain is overriding this reflex. When he allows the reflex to occur, urination occurs. A problem affecting this nerve pathway or the muscles of the bladder wall can cause neuropathic bladder dysfunction.
During cystometry, people bladder is filled with water or gas to measure its ability to hold in and

push out the water or gas. Medications may also be given to see whether your bladder contracts or relaxes normally in response to the medicine given. A small tube (catheter) can be placed in rectum to measure the abdominal pressure as the bladder fills. A small pad or needle may be placed near anus to measure muscle function in this area[6].

## Cystometry done to[7]:

- Find the cause of problems with the bladder or the muscle that holds urine in the bladder (bladder sphincter). Problems in one or both of these areas may cause leakage of urine (Urinary incontinence), a feeling that you have to urinate, or a weak urinary stream.
- Measure how much urine bladder can store and how much urine remains in bladder after people feel he has completely emptied it (urinary residual volume).
- Helps people and his doctor make decisions about how to treat his urinary symptoms.
- See how well the bladder works in people with progressive neurological diseases, such as multiple sclerosis.

Cystometry done in a doctor's office or hospital urology department by a urologist, gynecologist, or other trained health professionals.

- At the beginning of the series of tests, the patient will be asked to urinate into a toilet that is connected to a machine called uroflowmeter. This machine measures how much urine passes and how long it takes (urinary flow rate), The time and effort needed to start the flow of urine, the number of times patient start and stop the flow of urine, and the presence of dribbling near the end of urinating are also recorded.
- Next, the patient will be asked to lie on back on an examining table. After the urethra is thoroughly cleaned, a well-lubricated thin, flexible tube (catheter) is gently inserted and slowly advanced into the urinary bladder. Any urine remaining in bladder (residual volume) will be drained and measured.
- Another catheter may be placed in rectum to measure the pressure in the abdomen of the patient as his bladder fills. A small pad or needle may be placed near anus to measure muscle function in this area (sphincter function).
- For cystometry, the catheter is used to fill bladder with sterile, room-temperature saline water. The catheter is also attached to a device called a cystometer, which measures the pressure inside the urinary bladder (Vesical pressure). The patient will be asked to report any feelings such as warmth, bladder fullness, or an urge to urinate. The process may be repeated.
- 47 cases were tested in the device. 26 were female and the rest were male. The cases age was ranged from 17 to 42 year old, Analysis of the set of results were done to optimize the input and output to the neural network model designed to simulate the cystometry test, and the results with the commands of the examining urologist were learned also.

The constant parameters through all cases are tabulated in table.1

**Table 1: condition of the cystometry test (Constant parameters)**

| | | |
|---|---|---|
| 1 | Infusion medium: | Saline |
| 2 | Infusion rate : | 60ml/min |
| 3 | Infusion temperature : | $27^oC$ |
| 4 | Position : | Supine |
| 5 | Catheter type : | 6fr- 2 lumen |

The input and output parameters to the Training patterns were tabulated in table.2

**Table 2. Training patterns**

| IP No | input | | unites |
|---|---|---|---|
| 1 | Vesical Pressure | First Desire | (cm $H_2O$) |
| 2 | Abdominal Pressure: | | (cm $H_2O$) |
| 3 | Detrusor Pressure: | | (cm $H_2O$) |
| 4 | Infused Volume | | (ml) |
| 5 | Compliance | | (ml/ cm $H_2O$) |
| 6 | Vesical Pressure | Normal Desire | (cm $H_2O$) |
| 7 | Abdominal Pressure: | | (cm $H_2O$) |
| 8 | Detrusor Pressure: | | (cm $H_2O$) |
| 9 | Infused Volume | | (ml) |
| 10 | Compliance | | (ml/ cm $H_2O$) |
| 11 | Vesical Pressure | P.max | (cm $H_2O$) |
| 12 | Abdominal Pressure: | | (cm $H_2O$) |
| 13 | Detrusor Pressure: | | (cm $H_2O$) |
| 14 | Vesical Pressure | Infused Vol. | (cm $H_2O$) |
| 15 | Abdominal Pressure: | | (cm $H_2O$) |
| 16 | Detrusor Pressure: | | (cm $H_2O$) |

| OP No | Output Input | Unites (cases) |
|---|---|---|
| 1 | Uninhibited Urinary Reflex | No(0)or Yes(1)* |
| 2 | Compliance condition | Normal(2), low(1), high(3) or equivocal(0) |
| 3 | Contraction inhibited | No(0) or Yes(1) |
| 4 | Provocation | Crede(1), valsalva(2), cough(3), or nothing(0) |
| 5 | Max. infused Capacity | (ml) |
| 6 | Detrusor | Underactive(1), stable(2) or overactive(3) |
| 7 | neuropathic bladder condition | Upper neuropathic bladder lesion(1), lower neuropathic bladder lesion(2), or normal(0) |

*: number which input to the algorithm to represent the command case.

## *4. APPLICATION OF NEURAL NETWORK*

The results of 47 case studies were used for training a 16- 30- 7 back propagation neural network. The input and output data required for training the neural network shown in Table 2. The bias and weight factors were chosen randomly between -0.08 to 0.1. The neural network was trained for error tolerance of 0.218. It converged in 496842 epochs.

## *5. RESULTS & DISCUSSION:*

The trained neural network has been used for predicting the responses of unknown patterns. The input parameters of the unknown patterns are given in Table. 3 and the corresponding neural network predictions are given in Table. 4.

The maximum error in five predictions is 17 percent. It can be observed from the tables that most of the time, neural network predictions are very close to the test results. These errors can be further reduced by reducing the tolerance limit and increasing the training patterns. Maximum error is in the prediction of the max. Infused capacity, while no error was produced for the other output parameters because the neural network algorithm output was approached to the integer number representing the letter of command in the tested cases which is approximated to the representative number.

This approach of response prediction will help in quick determination of the behavior of cystometry test clinical results and may be developed as a learned computerized cystometry to assist the urologist to diagnose the patient's complaint.

**Table 3. Testing patterns**

| IP No | Input | Case No. | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|
| 1 | Vesical Pressure | First Desire | 5 | 7 | 4 | 2 | 4 | 2 |
| 2 | Abdominal Pressure: | | -35 | -1 | -26 | -44 | -9 | -28 |
| 3 | Detrusor Pressure: | | 40 | 8 | 30 | 46 | 13 | 30 |
| 4 | Infused Volume | | 148 | 152 | 199 | 162 | 137 | 151 |
| 5 | Compliance | | 4 | 19 | 7 | 4 | 11 | 5 |
| 6 | Vesical Pressure | Normal Desire | 22 | 13 | 4 | 3 | 4 | 2 |
| 7 | Abdominal Pressure: | | -35 | 7 | -27 | -48 | -15 | -30 |
| 8 | Detrusor Pressure: | | 57 | 6 | 31 | 51 | 19 | 32 |
| 9 | Infused Volume | | 199 | 280 | 228 | 263 | 224 | 198 |
| 10 | Compliance | | 4 | 47 | 7 | 6 | 12 | 7 |
| 11 | Vesical Pressure | Pmax | 49 | 52 | 40 | 4 | 57 | 25 |
| 12 | Abdominal Pressure: | | 0 | 18 | 2 | -1 | 18 | -1 |
| 13 | Detrusor Pressure: | | 85 | 38 | 71 | 55 | 53 | 53 |
| 14 | Vesical Pressure | Infused Vol. | 235 | 607 | 625 | 356 | 412 | 229 |
| 15 | Abdominal Pressure: | | 0 | 542 | 0 | 20 | 249 | 0 |
| 16 | Detrusor Pressure: | | 235 | 607 | 625 | 350 | 251 | 230 |

**Table 4. Predictions by neural network**

| Op No | Output | Case No. | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|
| 1 | Uninhibited urinary reflex | Real | 0 | 0 | 0 | 0 | 1 | 0 |
| | | NNT | 0 | 0 | 0 | 0 | 1 | 0 |
| | | e(100%) | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | Compliance condition | Real | 3 | 1 | 1 | 2 | 2 | 3 |
| | | NNT | 3 | 1 | 1 | 2 | 2 | 3 |
| | | e(100%) | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | Contraction inhibited | Real | 0 | 1 | 0 | 0 | 0 | 1 |
| | | NNT | 0 | 1 | 0 | 0 | 0 | 1 |
| | | e(100%) | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | Provocation | Real | 1 | 1 | 1 | 2 | 2 | 2 |
| | | NNT | 1 | 1 | 1 | 2 | 2 | 2 |
| | | e(100%) | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | Max. infused Capacity | Real | 235 | 608 | 626 | 404 | 510 | 280 |
| | | NNT | 270 | 559 | 571 | 341 | 425 | 309 |
| | | e(100%) | 15 | 8 | 9 | 16 | 17 | 10 |
| 6 | Detrusor condition | Real | 3 | 1 | 1 | 2 | 3 | 3 |
| | | NNT | 3 | 1 | 1 | 2 | 3 | 3 |
| | | e(100%) | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | neuropathic bladder condition | Real | 1 | 2 | 2 | 0 | 2 | 1 |
| | | NNT | 1 | 2 | 2 | 0 | 2 | 1 |
| | | e(100%) | 0 | 0 | 0 | 0 | 0 | 0 |

## *6. CONCLUSIONS*

In this study, clinical results of the cystometry tests of the urinary bladder have been predicted using artificial neural network.
The neural network is trained, based on the results of 47 cases examined and concluded with cystometry. Measured values of the device probes (pressure , volume compliance and case sensation) as input and uninhibited urinary reflex, Compliance condition, Contraction inhibited, Provocation, max-Infused Capacity, Detrusor and neuropathic bladder condition as output to the neural network. The trained neural network was tested for five new cases and compared with the experimental test results.
It was observed that the neural network gives quite close predictions of the clinical results of the cystometry tests.

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# مُحاكاة تَشخيص أمراضِ المثانةِ العصابيةِ باستخدامِ تِقَنيةِ الشبكة العصبيةِ البرمجيةِ


## الخُلاصة:

يُعتَبرُ جِهازُ فَحصِ المثانةِ أحدَ الوسائلِ المُهمة في تشخيصِ الامراضِ العَصبية للمثانة ومن خِلاله يُمكنُ استنتاجُ العلاجَ الامثل لمثلِ هذهِ الحالاتِ. الغرضُ منَ البحثِ هوَ تصميمُ شبكةً عصبيةً برامجيةً لـــديها القابليةُ على اعطاءِ التشخيصِ الاولي لحالاتِ المثانةِ العصبيةِ بكلِ انواعِها.

أجريَ العملُ في هذا البحثِ من خلالِ اختبارِ سبعة واربعين حالةِ مثانة عصابية مختلفةِ تم اختيارهـــا بشكل عشوائي في جهاز فحص وظائف المثانة لقياس المتغيرات التالية:

١. التَحَمُلية
٢. حجمُ المثانة
٣. القابلية التقلصية
٤. التحسُس
٥. السيطرة الارادية

ومن ثم شُخصت الحالاتُ من قبل طبيب اختصاص في جراحة المسالك البولية. هذه المتغيـــرات مـــع التشخيص الاولي أدخلت لتدريب برنامج حاسوبي لشبكة عصبية ثلاثية الطبقات صممت لهذا الغـــرض باستخدام برنامج matlab. تبعاً لذلكَ تم معالجةُ كلِ البياناتِ وتم اختبار قابليتها على معالجةِ حـــالاتِ مثانة عصابية مشخصة مسبقا ومدا صحتها في تفسيرِ التصرف العصبي للمثانـــة لـــذلك المـــريض ( اعطاء التشخيص الاولي لحالة المثانة العصبية).

وجُد من خلال تطابق النتائج العملية مع المحاكاة الحاسوبية لستة متغيراتهي كل من ( استجابة المثانـــة الغير مسيطر عليها، الاستيعابية ، قابلية الغاء التقلص للمثانة ، التواصلية ، حالة عضـــلات المثانـــة ، حالة المثانة العضلية) وتقارب مقبول بين الاختبارين وبنسبة خطأ اقصاها ١٧% بالنسبة لقيمة اقصـــى حجم للمثانة الممتلئة.

استُنتِج من خلال البَحث ان الشبكة العصبية البرامجية المصممة في هذا العملِ لـــديها القابليـــةُ علـــى استنتاج التشخيصِ الاوليِ لحالتِ المثانةِ العصابيةِ بشكل مقارب جداً للتشخيص الذي يمكن استنتاجهُ من جهازِ فَحصِ المثانةِ وطبيب الاختصاص.