Journal of Advances in Medicine and Medical Research

33(19): 139-150, 2021; Article no.JAMMR.73497
ISSN: 2456-8899
(Past name: British Journal of Medicine and Medical Research, Past ISSN: 2231-0614, NLM ID: 101570965)

Functional Brain Alterations in Individuals with Motor Conversion Disorder

Mai Ahmed Salem[1*], Mohammad Abdel Hakeem[1], Rasha Ahmed El Shafey[1], Gamal Ibrahim Taha shamma[1] and Ahmed Abdel Rahman Mubarak[1]

[1]Neuropsychiatry Department, Faculty of Medicine, Tanta University, Tanta, Egypt.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JAMMR/2021/v33i1931088
Editor(s):
(1) Prof. EminUmitBagriacik, Gazi University, Turkey.
Reviewers:
(1) Ana H. N. Beserra, Federal University of Rio de Janeiro, Brazil.
(2) Roshini Sathiaseelan, University Of Oklahoma Health Sciecnes Center, USA.
(3) Linda Varghese, Amrita Vishwa Vidyapeetham, India.
Complete Peer review History: https://www.sdiarticle4.com/review-history/73497

Original Research Article

Received 01 July 2021
Accepted 11 September 2021
Published 11 September 2021

ABSTRACT

Background: Conversion disorder (CD) is characterized by neurological symptoms affecting voluntary motor control and incompatible with organic damage to the nervous system. Since novel insights have been gained with the advent of functional magnetic resonance imaging, we aimed to explore potential functional alterations in various areas of the brain in a sample of Egyptian patients suffering from conversion disorder.
Methods: This cross-sectional study was carried out on patients who met the DSM-5 criteria for conversion disorder presented with weakness or paralysis aged from 18- 40 years old. Group A (Cases): include 30 patients with motor conversion disorder. Group B (Control): include 30 normal healthy individuals free from any psychiatric disorders. Structured Clinical Interview DSM-IV (SCID-I) and (SCID-II) were applied for psychometric evaluation.
Results: The cases had increased activity in the contralateral amygdala of the affected side of patients with CD. Cases also showed decreased activation of contralateral basal ganglia in the affected side as well as a decreased activity of the motor cortex contralateral to the affected side. There was a decrease in activation of SMA contralateral to the side of disability. There was an increase in the activity of the contralateral insula.
Conclusions: Functional abnormal alterations in motor and sensory systems are related to the presence of neurological symptoms in conversion disorder.

**Corresponding author: E-mail: thesismses@gmail.com;*

Keywords: Brain; Motor Conversion Disorder; CD; Neurological.

1. INTRODUCTION

Conversion disorder is classified as one of the "somatic symptom and related disorders" in the *Diagnostic and Statistical Manual of Mental Disorders of the American Psychiatric Association (DSM-5*) [1]. The *DSM-5* diagnostic criteria for conversion disorder include one or more symptoms of altered voluntary motor or sensory function, with clinical findings, provide evidence of incompatibility between the symptom and recognized neurological or medical conditions.

Conversion disorder, also called functional neurological symptom disorder, is characterized by neurological symptoms affecting voluntary motor control and incompatible with organic damage to the nervous system [2]**.** Conversion disorder is a frequent cause of disability, representing approximately 3-5% of all neurological outpatients. It is thought to be generated unconsciously, and often associated with underlying psychological stressors or trauma [3].

An association between physical symptoms and emotions has been understood since the early 19th century. According to learning theory, conversion disorder symptoms are explained as a learned maladaptive response to stress. In this view, patients are thought to achieve secondary gain by avoiding activities that are particularly offensive to them, thereby gaining support from family and friends, which otherwise may not be offered [4].

Novel insights have been gained with the advent of functional magnetic resonance imaging studies in patients suffering from conversion disorder. Evidence from neuventroimaging studies has implicated modulation of several neural structures that lie at the intersection of affective and motor processing; these studies indicate abnormalities outside the core motor network, including the prefrontal cortex and anterior cingulate cortex, the results support the hypothesis of abnormal inhibition of motor systems by limbic region [5]**.**

We hypothesize that the brains of patients with motor conversion disorder will be functionally different from those of normal healthy subjects in a pattern that helps us to understand the underlying causes of conversion disorder and to develop novel lines of diagnosis and treatment of the disorder.

Our work aimed to to explore potential functional alterations in various areas of the brain in a sample of Egyptian patients suffering from conversion disorder with motor symptoms and to identify the areas in which these changes are most manifest in comparison to normal control subjects by using fMRI.

2. PATIENTS AND METHODS

This cross-sectional study was conducted at Department of Neuropsychiatry and Center of Psychiatry, Neurology and Neurosurgery, Radiology Department, Tanta University Hospitals, Egypt. Approval from Institutional Review Board and informed written consent were obtained. The participants were classified into 2 groups. Group A (Cases): include 30 patients with motor conversion disorder. Group B (Control): include 30 normal healthy individuals free from any psychiatric disorders.

2.1 Inclusion Criteria

Both male and female patients who met the DSM-5 criteria for conversion disorder presented with weakness or paralysis aged from 18- 40 years old.

2.2 Exclusion Criteria

Patients who had any of the follwing:

1. Other co-morbid psychiatric disorders.
2. Neurological disorders.
3. Medical disorders that interfere with the interview (endocrine, liver cirrhosis, renal insufficiency).
4. Psychoactive drugs.
5. Intellectual disability.

All patients included in this study were subjected to complete demographic and medical history using El-Gilany and EL-Wasify scale and Perceived Stress Scale [6]. Clinical examinations were performed including psychometric interview and evaluation using the Structured Clinical Interview DSM-IV [7] (SCID-I) Arabic version was

used [8,9], functional MRI Brain and Neurological examination of cranial nerves, motor system coordination, superficial reflexes, deep reflexes, and the sensory system.

2.3 Statistical Analysis

Statistical presentation and analysis of the present study were conducted. Results were tabulated and statistical analysis was performed with Statistical Package for Social Science (SPSS) version 12. Comparison between the studied groups was performed using the mean, standard error, Chi-square, and Linear Correlation Coefficient and Student t-test. P value ≤ 0.05 was considered statistically significant.

3. RESULTS

There was no significant difference were detected between patients and control regarding age, gender, educational level, employment**,** marital state, and residence Table 1.

There was no significant difference was detected between the side of disability and each of gender, residence, occupation ,and educational level. However, there was a statistically significant difference between the Side of disability and personality traits Table 2.

There was no significant differences was detected between the severity of motor disability and each of gender, residence, occupation, educational level ,and personality traits.

There was no significant differences was found between the type of stress and gender, educational level , and personality traits. However, there was a statistically significant difference between the type of stress and occupation
Table **3**.

Table 1. Demographic distribution medical history of participants

			Patient (N=30)	Control (N=30)	Total	X^2		
						X2	df	P
Age		**Mean**	29.57	29.83		F= 4.002	58	0.50
		SD	7.583	6.063				
Gender	**Male**	**No**	18	15	33	X2=2.12	1	0.44
		%	60.0%	50.0%	55.0%			
	Female	**No**	12	15	27			
		%	40.0%	50.0%	45.0%			
Educational level	**Uneducated**	**No**	2	0	2	X2=2.12	3	0.55
		%	6.7%	0.0%	3.3%			
	Primary education	**No**	7	8	15			
		%	23.3%	26.7%	25.0%			
	Secondary education	**No**	9	10	19			
		%	30.0%	33.3%	31.7%			
	High education	**No**	12	12	24			
		%	40.0%	40.0%	40.0%			
Employment	**Employed**	**No**	25	23	48	0.42	1	0.52
		%	83.3%	76.7%	80.0%			
	Unemployed	**No**	5	7	12			
		%	16.7%	23.3%	20.0%			
Marital state	**Single**	**No**	11	11	22	4.38	3	0.11
		%	36.6%	36.6%	36.6%			
	Married	**No**	13	18	31			
		%	43.3%	60.0%	51.6%			
	Divorced	**No**	6	1	7			
		%	20.0%	3.3%	11.6%			
Residence	**Urban**	**No**	14	14	28	0.00	1	1.0
		%	46.67	46.67	46.67			
	Rural	**No**	16	16	32			
		%	53.33%	53.33%	53.33%			
Duration of illness (days)		**Mean**	150.50		30			
		SD	125.1916					

Table 2. Distribution of Side of disability according to different variables

			Right arm	Left arm	Left side	X2	df	P
Gender	**Male**	**No**	7	8	3	0.33	2	0.86
		%	63.6%	61.5%	50.0%			
	Female	**No**	4	5	3			
		%	36.4%	38.5%	50.0%			
Residence	**Urban**	**No**	7	5	2	2.05	2	0.36
		%	50.0%	35.7%	14.3%			
	Rural	**No**	4	8	4			
		%	25.0%	50.0%	25.0%			
Employment	**Unemployed**	**No**	2	2	1	0.03	2	0.99
		%	18.2%	15.4%	16.7%			
	Employed	**No**	9	11	5			
		%	81.8%	84.6%	83.3%			
Educational level	**Uneducated**	**No**	1	1	0	4.88	6	0.56
		%	9.1%	7.7%	0.0%			
	Primary education	**No**	3	2	2			
		%	27.3%	15.4%	33.3%			
	Secondary education	**No**	1	6	2			
		%	9.1%	46.2%	33.3%			
	High education	**No**	6	4	2			
		%	54.5%	30.8%	33.3%			
personality traits	**Histrionic**	**No**	10	8	2	6.06	2	0.05
		%	90.9%	61.5%	33.3%			
	Borderline	**No**	1	5	4			
		%	9.1%	38.5%	66.7%			

Table 3. Distribution of Side of Severity of motor symptoms and type of Stress according to different variables

			Difficulty to move	Inability to move	X2	df	P
Gender	**Male**	**No**	7	11	0.36	1	0.55
		%	53.8%	64.7%			
	Female	**No**	6	6			
		%	46.2%	35.3%			
Residence	**Urban**	**No**	6	8	0.00	1	0.96
		%	42.9%	57.1%			
	Rural	**No**	7	9			
		%	43.8%	56.3%			
Employment	**Unemployed**	**No**	3	2	0.68	1	0.41
		%	23.1%	11.8%			
	Employed	**No**	10	10			
		%	76.9%	76.9%			
Educational level	**Uneducated**	**No**	2	0	3.25	3	0.35
		%	15.4%	0.0%			
	Primary education	**No**	2	5			
		%	15.4%	29.4%			
	Secondary education	**No**	4	5			
		%	30.8%	29.4%			
	High education	**No**	5	7			
		%	38.5%	41.2%			
personality traits	**Histrionic**	**No**	8	12	0.27	1	0.60
		%	61.5%	70.6%			

	Borderline	**No**	5	5			
		%	38.5%	29.4%			
Type of Stress							
			Sudden stress	**Continuous stress**			
Gender	**Male**	**No**	8	10	1.12	1	0.28
		%	72.7%	52.6%			
	Female	**No**	3	9			
		%	27.3%	47.4%			
Employment	**Unemployed**	**No**	4	1	4.85	1	.028
		%	36.4%	5.3%			
	Employed	**No**	7	18			
		%	63.6%	94.7%			
Educational level	**Uneducated**	**No**	2	0	5.87	3	0.12
		%	18.2%	0.0%			
	Primary education	**No**	3	4			
		%	27.3%	21.1%			
	Secondary education	**No**	4	5			
		%	36.4%	26.3%			
	High education	**No**	2	10			
		%	18.2%	52.6%			
personality traits	**Histrionic**	**No**	7	13	0.07	1	0.79
		%	63.6%	68.4%			
	Borderline	**No**	4	6			
		%	36.4%	31.6%			

Table 4. Nonparametric statistics using Mann-Whitney and Wilcoxon W Test

Degree of activation	Group	No	Mean Rank	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
Contralateral motor cortex	Patient	30	17.98	74.50	539.50	-5.56	**0.00**
	Control	30	43.02				
Ipsilateral motor cortex	Patient	30	25.17	290.00	755.00	-2.37	**0.09**
	Control	30	35.83				
Contralateral supplementary motor cortex	Patient	30	17.13	49.00	514.00	-5.93	**0.00**
	Control	30	43.87				
Ipsilateral supplementary motor cortex	Patient	30	31.63	416.00	881.00	-0.50	0.64
	Control	30	29.37				
Contralateral insula	Patient	30	41.68	114.50	579.50	-4.97	**0.00**
	Control	30	19.32				
Ipsilateral insula	Patient	30	34.72	323.50	788.50	-1.88	0.06
	Control	30	26.28				
Contralateral basal ganglia	Patient	30	16.55	31.50	496.50	-6.19	**0.00**
	Control	30	44.45				
Ipsilateral basal ganglia	Patient	30	35.05	313.50	778.50	-2.02	**0.04**
	Control	30	25.95				
Contralateral amygdala	Patient	30	42.07	103.00	568.00	-5.13	**0.00**
	Control	30	18.93				
Ipsilateral amygdala	Patient	30	26.02	315.50	780.50	-1.99	**0.04**

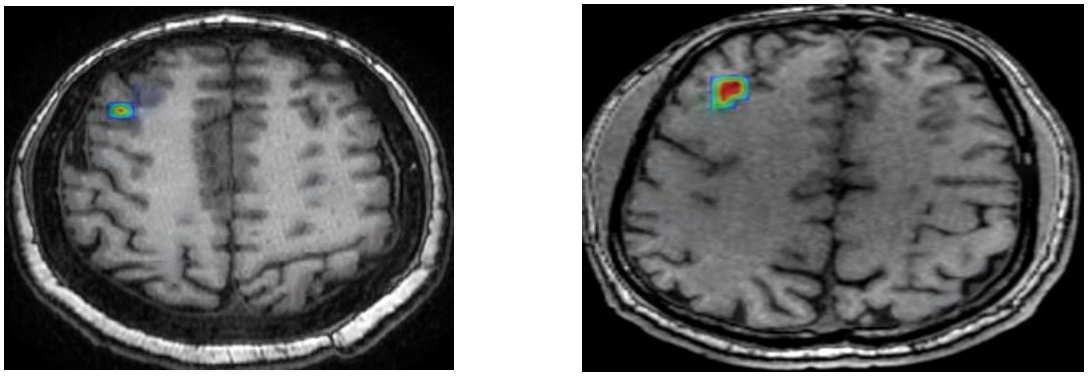
There was a significantly low rank in the mean degree of activation in the patient than control in the contralateral motor area, ipsilateral motor area, contralateral supplementary motor area,

contralateral basal ganglia, ipsilateral basal ganglia and increased mean degree of activation in contralateral insula and contralateral amygdala, and ipsilateral amygdala. Boxplot graphs were done for more illustration of quartile distribution Table 4.

There was a significant affection on the degree of activation, it affects the degree of activation of the contralateral motor cortex, contralateral supplementary motor cortex, contralateral insula, contralateral basal ganglia and contralateral amygdala Table 5.

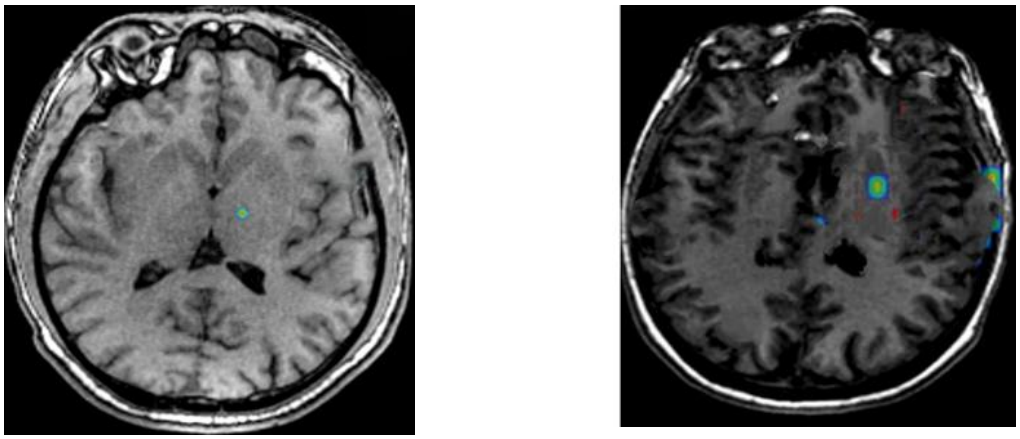
Table 5. Model summary of the independent variables as a predictor of degree of activation

ROI	R Square	F	df1	df2	P
Contralateral motor cortex	0.93	32.69	9	21	**<0.001**
Ipsilateral motor cortex	0.98	115.89	9	21	**<0.001**
Contralateral supplementary motor cortex	0.93	32.69	9	21	**<0.001**
Ipsilateral supplementary motor cortex	0.96	65.12	9	21	**<0.001**
Contralateral insula	0.97	83.78	9	21	**<0.001**
Ipsilateral insula	0.94	43.45	9	21	**<0.001**
Contralateral basal ganglia	0.93	32.69	9	21	**<0.001**
Ipsilateral basal ganglia	0.97	79.55	9	21	**<0.001**
Contralateral amygdala	0.96	68.12	9	21	**<0.001**
Ipsilateral amygdala	0.96	61.07	9	21	**<0.001**



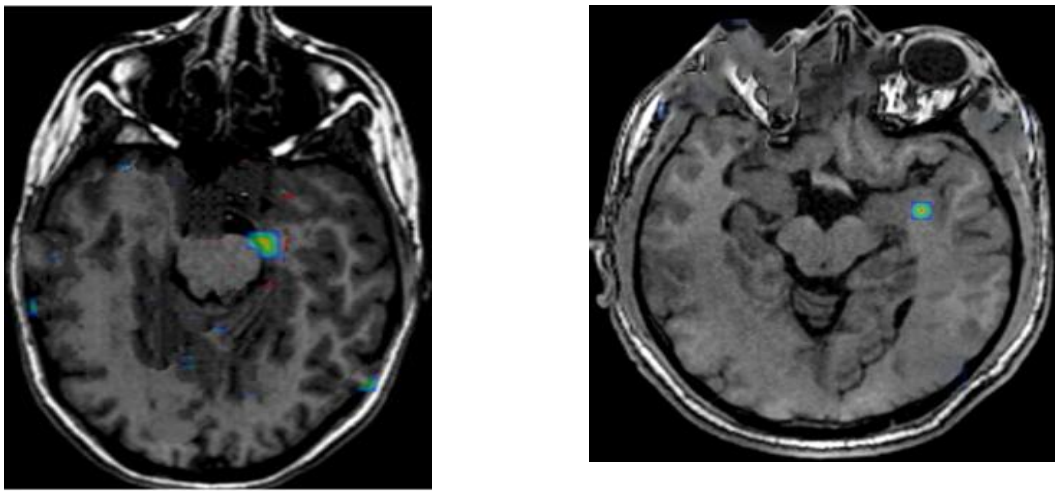
Patient Control

Fig. 1. Comparison between degree of activation of contralateral motor cortex in patients and control



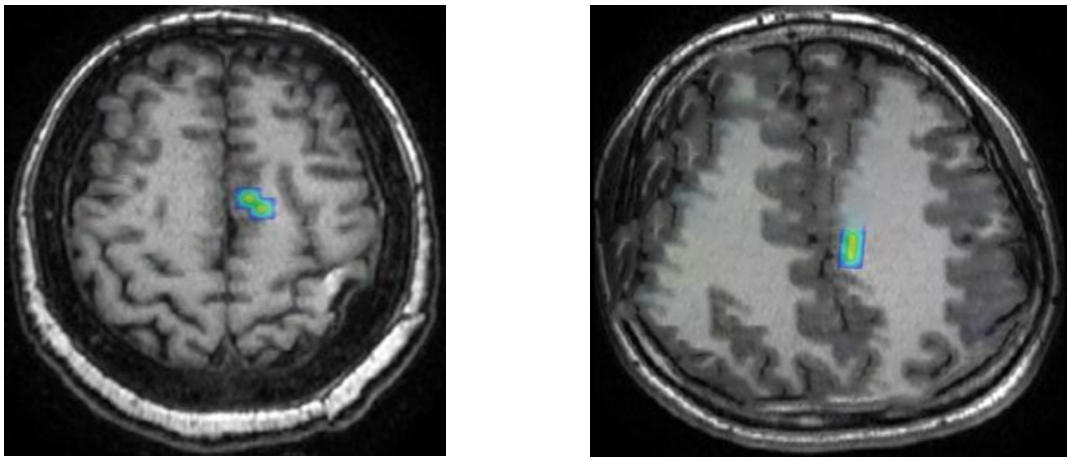
Patient Control

Fig. 1. Comparison between degree of activation of basal ganglia in patients and control



Patient Control

Fig. 2. Comparison between degree of activation of amygdala in patients and control



Patient Control

Fig. 3. Comparison between the degree of activation of the contralateral supplementary motor area in patients and control

This table shows that age and duration of illness affect the degree of activation of contralateral motor cortex, age and gender significant affection of the degree of activation of ipsilateral motor cortex, age and duration of illness show significant affection of the degree of activation of contralateral supplementary motor area, educational level show significant affection of degree of activation of ipsilateral supplementary motor area, age and duration of illness show significant affection of degree of activation of ipsilateral insula, age, type of stress and educational level show significant affection of degree of activation Ipsilateral basal ganglia and age show significant affection of degree of activation of contralateral amygdala **Error! Not a valid bookmark self-reference.**.

4. DISCUSSION

This study was conducted on 30 patients with conversion disorder (functional neurological disorder) in comparison to 30 controls. The aim was to detect the functional imaging changes during conversion and comparing them with control. We selected 6 brain areas viz; motor cortex, supplementary motor cortex, insula, basal ganglia and amygdala to be regions of interest (ROI).

Most of the previous similar studies had approximately the same mean age [10-12]. Another study of Deveci and colleges reported

that the prevalence of conversion disorder is high among young age of 18-25 years old [13].
The mean duration of illness in the current study was 150.0 days. This may reflect the fact that chronic stress might have precipitated symptoms of conversion disorder in our patients' life. In agreement with this finding, a study by Espay et al. reported that the long duration of symptoms of some cases might be attributed to delayed diagnosis of motor conversion disorder [14].

As regards the correlation between type of stress and duration of illness, there was significant correlation between type of stress and duration of illness. We reported that long duration of symptoms was correlated with chronic type of stress. Our finding is going with the study of [15] who reported that duration of illness is positively correlated with chronic exposure to stress. Another study of Perez and colleges reported that there was increase in duration of illness with acute type of stress. That may be attributed to the fact that the acute presence of stress is associated with more and severe symptoms that may persist for a longer time [16].

Regarding functional brain-imaging results, we found significant differential activation in Regions Of Interest (ROI) previously discussed concerning CD. The current results of our study suggest functional differences between patients with CD and healthy controls in the amygdala, primary motor cortex, basal ganglia, supplementary motor area, and amygdala. In agreement with our study, Voon and colleges and Aybek and colleges reported a significant difference in the area of activation between the patients and control group [17,18].

Previous studies by Eickhoff, et al. and Boeckle and colleges reported that emotional, motor planning, and inhibitory processes are involved in CD. Instead of single miss-functioning of a specific neuroanatomical area, a complete network of areas seems to influence the presentation of CD symptoms [19,20].

Regarding the nature and degree of activation, there was a significant difference between the patient group and control group. The finding clearly demonstrate that the brain area like motor and basal ganglia that involved in control the motor component of CD show decrease while those involved in control of emotional component show increased activation. Previous studies reported similar results and Boeckle, et al. as they found decreased activation of motor cortex contralateral to the affected side [20-22].

Table 6. The predictors of degree of activation of regions of interest

ROI	: Predictors of Degree of activation	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	SD	Beta		
Contralateral motor cortex	Age	0.065	0.025	0.56	2.56	0.018
	Duration of illness	-0.011	0.004	-0.62	2.99	0.007
Ipsilateral motor cortex	Age	0.088	0.021	0.49	4.15	<0.001
	Gender	0.741	0.346	.204	2.14	0.044
Contralateral supplementary motor cortex	Age	0.065	0.025	0.56	2.56	0.018
	Duration of illness	-0.011-	0.004	-0.62	2.99	0.007
Ipsilateral supplementary motor cortex	Educational level	0.623	0.257	0.38	2.42	0.024
Ipsilateral insula	Age	0.055	0.025	0.42	2.18	0.040
	Duration of illness	-0.009-	0.004	-0.41	2.29	0.032
Contralateral basal ganglia	Age	0.060	0.022	0.59	2.70	0.013
	Type of stress	-2.464-	1.115	-1.37	2.21	0.038
	Educational level	0.601	0.211	0.62	2.85	0.009
Ipsilateral basal ganglia	Age	0.062	0.025	0.36	2.53	0.020
	Educational level	0.512	0.235	0.31	2.18	0.041
Contralateral amygdala	Age	0.061	0.027	0.35	2.30	0.032

Another FMRI study by Shimada et al. also investigated differences in functional connectivity of the right and left motor cortex depending on the nature of motor dysfunction [23]. They found that in normal conditions (healthy controls), activity in the motor area was selectively coupled with a network of regions implicated in motor control including premotor cortex (PMC), and medial supplementary motor area (SMA). In patients with motor conversion, the same connectivity pattern was found for motor cortex contralateral to the intact hand, whereas motor cortex contralateral to the affected hand showed reduced functional connectivity. This suggests that motor control is somehow under the influence of internal representations related to self-relevant emotional information or memory in patients with symptom conversion of voluntary movements.

We reported decreased activity of the motor cortex contralateral to the affected side in comparison to the motor cortex contralateral to the healthy side in the patients. In agreement with our study, Markus and colleges reported similar results [15,24]. In contrary to our findings, increased motor cortex activation in the contralateral side is compared to the ipsilateral side in relationship to the affected side [5,25]. This difference might be dependent-task.

In the current study, we reported increased activity in the contralateral amygdala of the affected side of patients with CD in comparison to healthy controls. The amygdala is known to be involved in autonomic responses, including freezing behavior, attention, vigilance and arousal changes [25].

Two previous studies by Voon, et al. showed increased activity in the amygdala of patients with CD in comparison to healthy controls [17,22].

Aybek and colleges discussed that the increased activation in the amgdala might be based on active memory suppression during the recall of unwanted memories [18]. Increased activation in patients with CD was also reported during working memory studies in the motor cortex.

Seignourel, et al. reported normal potentiation of the startle eyeblink response (a protective reflex following abrupt stimuli) following unpleasant stimuli in CD, but potentiated responses following pleasant stimuli, rather than startle inhibition as seen in controls, indicating aversive physiological reactivity to both negative and positive emotions in these patients [26].

Blakemore and colleges reported that there was no difference between the activation of amygdala groups {Blakemore, 2016 #38}. The comparison between affected side activation and the unaffected side showed increased activation of amygdala contralateral to the affected side in our study that support the role of amygdala in psychological and physiological arousal in pathophisology of motor conversion disorder. Boeckle, et al. reported results similar to that reported in our study [27].

In current study, we reported decreased activation of contralateral basal ganglia in the affected side in patients as compared to the control group providing direct evidence of functional abnormalities in sensorimotor pathways specifically related to the presence of subjective neurological symptoms. We also reported decreased activation in basal ganglia contralateral to the affected side in comparison to healthy side. Similar results were reported in the study by [28] as they reported decreased activation of basal ganglia. Decreased activity in basal ganglia might set the motor system in a functional state characterized by impaired motor readiness and initiation, resulting in abnormal voluntary behavior. In contrary, Stone, *et al* reported more activation in basal ganglia in comparison to control group when trying to move their weak ankle compared with their healthy side [15].

The supplementary motor area (SMA) has an important role in the selection, preparation and sequencing of voluntary real and imagined movements. In the current study, we reported a decrease in the degree of activation of the contralateral SMA to the side of disability in patients in comparison to control group. Multiple previous reports came in agreement with our finding [15,27]. Kanaan, et al reported increased activation of SMA contralateral to side of disability in patients; he reported increase the functional connectivity between SMA and amygdala [29]. This study supported the link between emotional processing and CD showing altered activation of brain areas involved in emotional processing and increased functional connectivity between emotional and movement–related brain areas.

In the current study, we reported an increase in the activity of contralateral insula in patients in comparison to healthy control. This can be

explained by the fact that insula is responsible for attention and motor inhibition system. Both attention and motor inhibition processes are triggered during passive movement of the hand. [12,30] reported similar results. This finding underlines the importance of the insula in motor conversion disorder and argues for a role for this brain area in monitoring motor inhibition.

Another study by Markus, et al. reported an increased activation of the insula in the context of potential motor-limbic network {Boeckle, 2016 #22}. They argued that the insula is involved in the subjective representation of internal body and feeling states during motor selection. Werring, et al. reported no difference in the degree of activation of insula in patients and control group, that could be due to different methodology {Werring, 2004 #40}.

The comparison between the insula contralateral to the side of disability to the insula of same side in the patients's group showed increased activation of contralateral insula, a finding that might reflect the involvement of insula in the experience of emotions. In agreement with our finding, reported that the insula showed significantly increased activity when the affected side was tested [31]. This region, which is continuous with the primary gustatory cortex, might be involved in the experience of emotions. Additionally, it is an important integrator of multimodal stimuli responsible for interfacing internal motivational states and external information.

In the current study, a regression model was created to identify the predictors that might predict the degree of activation in ROI in patients of motor conversion disorder.

We reported that this model has a significant contribution to the degree of activation of ROI (contralateral, ipsilateral motor cortex, contralateral, ipsilateral basal ganglia, contralateral, ipsilateral amygdala, contralateral, ipsilateral insula and contralateral, ipsilateral SMA).

A study of Binzer, et al. used sex, schooling (primary, high , or university), presence of personality disorder, and high Hamilton score (upper quartile) as independent variables [32]. The overall prediction was 78.33% correct in the model. A study by Atmaca, et al. used a group of independent variables as age, duration of illness and family history to predict the degree of activation in contralateral and ipsilateral basal ganglia, ipsilateral motor cortex, contralateral SMA and contralateral, ipsilateral motor cortex [28].

In the current study, we found the age was a predictor for degree of activation in contralateral, ipsilateral motor cortex, contralateral SMA, ipsilateral insula, contralateral and ipsilateral basal ganglia in the patients of conversion disorder. Older age was related to increased degree of activation in the motor cortex and basal ganglia contralateral to the side of affection. In agreement with our finding [28] reported that the younger age of onset is related to decreased degree of activation of contralateral and ipsilateral basal ganglia, ipsilateral motor cortex, contralateral SMA and contralateral, ipsilateral motor cortex. In contrary, Kanaan, et al. found that age has no effect on degree of activation of ROI in motor conversion disorder [29].

We also reported that chronic type of stress was related to decreased activation in contralateral basal ganglia. This can be explained by the longer period of exposure to stress that leads to changes in the plasticity of brain circuits which in turn causes changes in the degree of activation of brain areas. In agreement with our results, Eickhoff et al. reported that chronic type of stress was related to the degree changes in fMRI of the patients of motor conversion disorder [19]. In a study by Werring, et al., they reported that acute type of stress is associated with decreased activation of the contralateral motor cortex and contralateral SMA [33].

In the current study, we found that a longer duration of symptoms is related to a decrease in the degree of activation in the contralateral motor cortex, contralateral SMA and ipsilateral insula. In agreement with our results de Lange, et al. reported that increased duration of symptoms is related to the decrease in degree of activation of the contralateral motor cortex [5]. Another study by Boeckle, et al 2016 found that increased duration of symptoms was associated with the decreased degree of activation of the contralateral motor cortex and contralateral SMA {Boeckle, 2016 #22}. In contrary, Atmaca, et al. found that duration of illness did not affect the degree of activation of basal ganglia, motor cortex, amygdala, insula , or motor cortex [28]. In contrary, a study of Criaud, et al. reported that increased duration of illness is a predictor of increase degree of activation of the contralateral

motor cortex, contralateral SMA [34]. That may be attributed to different task paradigms used during FMRI study.

In this study, we tried to test the hypothesis that the brains of patients with motor conversion disorder could be functionally different from those of normal healthy subjects. We did find this difference and we tried to explain that in the context of the studied areas. Long way of research still needs to settle the cause-effect relationship of our findings.

5. CONCLUSIONS

Functional abnormal alterations in motor and sensory systems are related to the presence of neurological symptoms in conversion disorder.

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the authors.

CONSENT

As per international standard or university standard, patients' written consent has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. APA. Diagnostic and Statistical Manual of Mental Disorders Washington, DC2013.
2. Vuilleumier P. Hysterical conversion and brain function. Prog Brain Res. 2005;150: 309-29.
3. Scott RL, Anson JG. Neural correlates of motor conversion disorder. Motor Control. 2009;13:161-84.
4. Harvey SB, Stanton BR, David AS. Conversion disorder: towards a neurobiological understanding. Neuropsychiatr Dis Treat. 2006;2:13-20.
5. de Lange FP, Roelofs K, Toni I. Increased self-monitoring during imagined movements in conversion paralysis. Neuropsychologia. 2007;45:2051-8.
6. El-Gilany A, El-Wehady A, El-Wasify M. Updating and validation of the socioeconomic status scale for health research in Egypt. East Mediterr Health J. 2012;18:962-8.
7. First MB. User's guide for the structured clinical interview for DSM-IV axis II personality disorders: SCID-II: American Psychiatric Pub; 1997.
8. El Missiry A, Sorour A, Sadek A, Fahy T, Abdel Mawgoud M, Asaad T. Homicide and psychiatric illness: an Egyptian study [MD thesis]. Cairo: Faculty of Medicine, Ain Shams University. 2003.
9. Hatata H, Abou Zeid M, Khalil A, Okasha T. Dual diagnosis in substance abuse, a study in an Egyptian sample. MD Thesis, Ain Shams University. 2004.
10. Bell V, Oakley DA, Halligan PW, Deeley Q. Dissociation in hysteria and hypnosis: evidence from cognitive neuroscience. J Neurol Neurosurg Psychiatry. 2011;82: 332-9.
11. Perez DL, Barsky AJ, Daffner K, Silbersweig DA. Motor and somatosensory conversion disorder: a functional unawareness syndrome? J Neuropsychiatry Clin Neurosci. 2012;24: 141-51.
12. Hassa T, de Jel E, Tuescher O, Schmidt R, Schoenfeld MA. Functional networks of motor inhibition in conversion disorder patients and feigning subjects. Neuroimage Clin. 2016;11:719-27.
13. Deveci A, Taskin O, Dinc G, Yilmaz H, Demet MM, Erbay-Dundar P, et al. Prevalence of pseudoneurologic conversion disorder in an urban community in Manisa, Turkey. Soci psychiatry and psychiatric epidemiology. 2007;42:857-64.
14. Espay AJ, Aybek S, Carson A, Edwards MJ, Goldstein LH, Hallett M, et al. Current Concepts in Diagnosis and Treatment of Functional Neurological Disorders. JAMA Neurol. 2018;75:1132-41.
15. Stone J, Zeman A, Simonotto E, Meyer M, Azuma R, Flett S, et al. FMRI in patients with motor conversion symptoms and controls with simulated weakness. Psychosom Med. 2007;69:961-9.
16. Perez DL, Barsky AJ, Daffner K, Silbersweig DA. Motor and somatosensory conversion disorder: a functional unawareness syndrome? J Neuropsychiatry Clin Neurosci. 2012;24: 141-51.
17. Voon V, Brezing C, Gallea C, Ameli R, Roelofs K, LaFrance WC, Jr., et al. Emotional stimuli and motor conversion disorder. Brain. 2010;133:1526-36.

18. Aybek S, Nicholson TR, Zelaya F, O'Daly OG, Craig TJ, David AS, et al. Neural correlates of recall of life events in conversion disorder. JAMA Psychiatry. 2014;71:52-60.
19. Eickhoff SB, Laird AR, Grefkes C, Wang LE, Zilles K, Fox PT. Coordinate-based activation likelihood estimation meta-analysis of neuroimaging data: a random-effects approach based on empirical estimates of spatial uncertainty. Hum Brain Mapp. 2009;30:2907-26.
20. Boeckle M, Liegl G, Jank R, Pieh C. Neural correlates of conversion disorder: overview and meta-analysis of neuroimaging studies on motor conversion disorder. BMC Psychiatry. 2016;16:195.
21. Marshall JC, Halligan PW, Fink GR, Wade DT, Frackowiak RS. The functional anatomy of a hysterical paralysis. Cognition. 1997;64:B1-8.
22. Voon V, Brezing C, Gallea C, Hallett M. Aberrant supplementary motor complex and limbic activity during motor preparation in motor conversion disorder. Mov Disord. 2011;26:2396-403.
23. Shimada T, Ohi K, Yasuyama T, Uehara T, Kawasaki Y. Cerebellar activation during a motor task in conversion disorder with motor paralysis: A case report and fMRI study. Neuropsychopharmacol Rep. 2018; 38:47-50.
24. Van Beilen M, De Jong BM, Gieteling EW, Renken R, Leenders KL. Abnormal parietal function in conversion paresis. PLoS One. 2011;6:e25918.
25. Roelofs K, de Lange FP, Toni I. Motor imagery: A window into the mechanisms and alterations of the motor system. Cortex. 2008;44:494-506.
26. Seignourel PJ, Miller K, Kellison I, Rodriguez R, Fernandez HH, Bauer RM, et al. Abnormal affective startle modulation in individuals with psychogenical movement disorder. Mov Disord. 2007;22:1265-71.
27. Boeckle M, Schrimpf M, Liegl G, Pieh C. Neural correlates of somatoform disorders from a meta-analytic perspective on neuroimaging studies. NeuroImage Clin. 2016;11:606-13.
28. Atmaca M, Aydin A, Tezcan E, Poyraz AK, Kara B. Volumetric investigation of brain regions in patients with conversion disorder. Prog Neuropsychopharmacol Biol Psychiatry. 2006;30:708-13.
29. Kanaan RA. Freud's hysteria and its legacy. Handb Clin Neurol. 2016;139:37-44.
30. Chambers CD, Garavan H, Bellgrove MA. Insights into the neural basis of response inhibition from cognitive and clinical neuroscience. Neurosci Biobehav Rev. 2009;33:631-46.
31. Craig AD. How do you feel--now? The anterior insula and human awareness. Nat Rev Neurosci. 2009;10:59-70.
32. Binzer M, Andersen PM, Kullgren G. Clinical characteristics of patients with motor disability due to conversion disorder: a prospective control group study. J Neurol Neurosurg Psychiatry. 1997;63:83-8.
33. Werring DJ, Weston L, Bullmore ET, Plant GT, Ron MA. Functional magnetic resonance imaging of the cerebral response to visual stimulation in medically unexplained visual loss. Psychol Med. 2004;34:583-9.
34. Criaud M, Boulinguez P. Have we been asking the right questions when assessing response inhibition in go/no-go tasks with fMRI? A meta-analysis and critical review. Neurosci Biobehav Rev. 2013;37:11-23.

© 2021 Salem et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle4.com/review-history/73497