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The neuropsychological basis of delusions

A man is a system which is functioning as the whole and any organic changes, especially changes of the central nervous system, have an influence on the psychical functioning of a human. There are numbers of papers describing schizophrenia as a disease of the brain whose pathophysiology is still a mystery despite intensive investigation. A milestone in search of neuropsychological etiology of schizophrenia was the study of Johnstone et al. (12), who noticed ventricular enlargement in CT scans of schizophrenia patients. Many scientists confirmed this discovery, which was treated as a sign of neurodegeneration etiology (4). Neuropathological studies of schizophrenia patients showed not only ventricular enlargement but enlargement of globus pallidus and striatum as well. Beckman (1) claimed that such cytoarchitectonic abnormalities derived from disturbances of prenatal cell migration within the central nervous system. It is possible that mothers viral infections during the second trimester of the prenatal period as well as other harmful agents play an important role in the origin of those anatomical changes. It is believed that those exogenous noxious agents overlap a genetic predisposition. It is probable that there is no decrease in numbers of neurons but decrease in ramification of dendritic cells which results in a reduction of interneuronal neuropil and dopaminergic activity (16). Recently some authors emphasize the relationship of schizophrenia with amygdala abnormalities in schizophrenia patients and their relatives (18).

There is another theory regarding ventricular enlargement. It is believed that it is a result of neurodevelopment abnormalities. This theory is based on findings of DeLisi et al. (6), who noticed that some morphological changes of the brain might be present at the time of the first episode of schizophrenic-like psychosis and developed in the course of illness. Furthermore, Weinberger et al. (20) found that worse premorbid adjustment of schizophrenia patients is connected with brain atrophy visible in CT scans. Those findings were confirmed by Harvey et al. (9) by the use of MRI. Moreover, Walker et al. (19) were analyzing motor activity of schizophrenia patients and their healthy siblings in childhood. They found that worse motor activity and affectivity during childhood is related to ventricular enlargement in schizophrenia patients in comparison to their healthy twins.

Difficulties in delineating the neuroanatomy of schizophrenia is related both to the subtle nature of the neuropathological changes and the failure in addressing adequately the pathophysiological schizophrenia heterogeneity. Buchanan and Carpenter (2) propose a new methodological issue – searching for neuropathological changes characteristic not of a nosological entity but of psychopathological symptoms of such changes. However, it is not easy during differentiation of primary versus secondary symptoms, state versus trait characteristics, and categorical versus continuous variables must be taken into consideration.

The aim of this paper was to show different opinions present in the literature concerning the connection between delusions and hallucinations and neurological brain changes as well as mental disorders resulting from such changes.

MATERIAL AND METHODS

In this paper studies concerning neuropsychological basis of delusions from 1969 till 2005 were analyzed.

RESULTS

There is a theory describing formation of schizophrenia positive symptoms in four stages: 1) changes of such brain structures as hippocampus, amygdaloid nuclei, frontal and temporal cortex; 2) neurochemical abnormalities – intensive conduction of dopaminergic afferent fibres; 3) cognitive difficulties due to described above changes and 4) appearance of productive symptoms typical of acute psychosis. This theory is based on post-mortem findings in the limbic system of schizophrenia patients. On the neurochemical level this theory is supported by antypsychotic medications studies which show a connection between dopaminergic transmission and psychopathological symptoms. Assumptions of this theory are based on empirical proofs. The limbic system uses permanently storage information to hypothesize what will be the next state of the world. Afterwards the limbic system is comparing this hypothesis to the actual state of affairs. The result of such comparison is conducted from subiculum to thalamus *nucleus accumbens* which is part of acting programming system. According to Gray (7) schizophrenia disturbs the normal transmission between subiculum and thalamus *nucleus accumbens* which leads to nuerochemical abnormalities, that is mesolimbic tract hyperactivity. The psychological signs of such hyperactivity are frequent apparently unknown, that is unexpected, situations causing appearance of psychosis signs since the system responsible for information processing is inefficient in such position.

Sometimes changes in anatomical structure of the brain are responsible for occurrence of delusions and sometimes not. It is not unambiguously settled. It seems that the place and extensiveness of brain injury play a role in this phenomenon. On the other side, a role of other factors cannot be underestimated. Unequivocally the empiric statement that organic changes of brain structures result in delusions would solve a problem of delusions genesis. Until now there is not such a statement and delusions are seen in patients who do not have any visible brain injuries. It is possible that there is a predisposition in some people to develop delusions. Those predispositions might be as follows: psychosomatic genetic constitution, brain microinjuries, peculiar personality disorders (e.g. avoidant personality, paranoid personality, etc.) and stressful situations. Delusions might be a result of internalized childhood experiences especially those very scathing like for example ashamedness, faultfinding and feeling of adults dominance. One of psychopathological feeling might be a sense of "unfriendly or hostile group of people".

There are reports that the environment has an influence on brain development. However, it is very difficult to prove empirically that the environment plays a role in the origin and presence of delusions. There is a well known conception that genetic and such environment factors as birth and life in big cities have an influence on schizophrenia occurrence. The urbanized environment has physicochemical (air and water pollution), biological and psychosocial effects (11). Van Os (17) suggests that families in big cities are less coherent and social relationships are more loose in cities than in rural or provincial areas. Furthermore, people in big cities have a minor sense of safety and are more often exposed to stress. Stressful life is responsible for dysregulation of the dopaminergic system, which might result in occurrence of schizophrenia (10).

The statement that delusions occur in some brain diseases and can be evoked by some chemical substances might suggest that delusions are connected with morphological or anatomical brain changes. This direction of studies did not reveal the genesis of delusions, however, there are many theoretical and empirical papers that should be mentioned. An analysis of those papers shows two main approaches to this problem. In the first approach researchers first affirm organic brain changes and then they look for delusions. In the second approach first the occurrence of delusions is confirmed and then organic brain changes are looked for. According to the first approach psychosis with delusions is especially common in the course of extrapyramidal system

diseases, e.g. Huntington's disease, Wilson's disease or Parkinson's disease. In the course of SM psychotic syndromes were observed as well, especially during exacerbation of a disease (8).

Epileptogenic focuses localized in temporal-limbic area evoke schizophrenic-like psychosis with delusions, however, it is more often observed in patients with injuries of the left side of the brain. Neoplasmas and vascular injuries evoke delusions when comprise brain temporal lobe and subcortex structures. In papers concerning the limbic system differences in symptomatology were observed considering place of injury. Injury of the left hemisphere is connected with schizophrenic - like symptomatology and right hemisphere injury with short-lived delusions and hallucinations syndromes (8, 14).

It was hypothesized that the occurrence of delusions and hallucinations in patients with injury of temporooccipitalis area is connected with abnormalities in the stimuli transmission to the limbic system. It is possible that focal left temporal cortex injuries have an influence on verbal – intermediary functions which are responsible for a more frequent occurrence of delusions while this area is injured. Observations of patients with left hemisphere injuries supported the described above hypothesis. The relationship between disintegration of left hemisphere activity and disorders of events sequence perception was observed. It might be the reason that the patients had an impression that events overlap. Such a disintegration might result in fragmentary stimuli perception, therefore patients might feel changed somehow and they could receive the world as unreal. The second approach has many supporters as well. It was affirmed that Schneider's First-Rank Symptoms such as thought insertion , thought broadcast and thought withdrawal have been noticed in patients affected with hypothyreosis, extrapyramidal diseases and limbic system dysfunctions.

Capgras Syndrome, i.e. the situation in which a person is convinced that one or several persons have been replaced by a double, an identical looking imposter, was observed in patients who suffered from vitamins deficiency, endocrine glands disorders and patients with right hemisphere focal lesions. Fregoli Syndrome, a delusion that other people, even strangers, can become people the patient knows was observed in epileptic patients and delusions of infestation, heautoscopy and erotomany in epileptic patients and patients suffering from toxic-metabolic disorders (8).

Othello syndrome might be a symptom of endogenous psychosis, however, it might develop during long-lasting alcohol intoxication. Such a syndrome was observed in patients with metabolic disorders of the central nervous system, at the beginning of Alzheimer's disease and in the course of encephalitis, multiple sclerosis or epilepsy. Delusions of grandeur are present in psychoorganic syndromes which cause hypomaniacal mood. In such syndromes changes can be found in basal nuclei, hypothalamus area and frontal lobe.

Those anatomical observations lead to delusions origin hypothesis: the majority of researchers think that there is a connection between delusions and left hemisphere disorders since the left hemisphere is responsible for cognitive and linguistic processes, whereas the right hemisphere is accountable for visual-spatial processes and nonverbal learning. Both hemispheres cooperate with the limbic system whose role is to give emotional meaning to different experiences. The limbic system has close connections to subcortex nuclei and together with them creates limbic-basal integrated system which mediates in mood and motivation formation. Dysfunctions of the limbic system or subcortex nuclei may lead to strong, changeable emotions which can result in dysfunctions of the healthy hemisphere and occurrence of complex delusions. It is thought that in such cases limbic and subcortex dysfunctions are placed in such a way that they damage dopaminergic transmission. One of schizophrenia theories says that schizophrenia is strongly connected with hyperactivity of dopaminergic transmission, especially within the limbic system. This theory is supported by the fact that there is a similarity between schizophrenic delusions and delusions present in the course of the limbic system or subcortex brain structures diseases.

Kingsbourne et al. (13) have affirmed that there are specialized areas and groups of cells in the brain which originate from phylogenesis and ontogenesis. Such a specialization is very important for human behaviour since working of separate parts of the brain is not responsible for specific behaviour. There are different kinds of behaviour as an effect of varied parts of the brain

synergy as well as brain disorders resulting from various brain parts dysfunctions. It is much more known about interaction of functional brain systems by dint of Kingsbourne et al. In their study Mojtabai et al. (15) compared by means of neuropsychological tests battery the neuropsychological functioning of schizophrenia patients with that of psychotic affective disorders patients. Results of this study showed that subjects with schizophrenia performed worse than those from control group. The most consistent differences were in concentration, tests of attention, and mental tracking which authors link with decrease in capacity of cortex gray matter in associative areas.

Chee et al. (3) affirmation that there is common semantic net for processing optical and aural stimuli is based on functional MRI studies. Such a network is localized in the lower left frontal region, bilaterally in prefrontal region, in premotorial region and in cerebellum. Optical and aural stimuli activate common semantic system in posterior temporal region. It seems then that the storage of knowledge is independent of sensorial modality.

The aim of David and Howard's (5) work was to explain the essence of delusional memory. It is known that healthy people have problems to answer a question if specified event has happened for sure or not. However, healthy people have an introspective control mechanism which enables distinction between real and unreal events. Delusional memory is an example of psychopathological symptom characteristic of schizophrenia. Old descriptions distinguish primary delusions which occur idiosyncratically and those connected with perception of a real event which turned into delusions as a result of phenomenon called "false memory".

It is known that hallucinations and delusions might be treated as points on the continua function, where at one end there is the "norm" – lack of symptoms and at the other end there is maximal exacerbation of symptoms. There are studies which helped to make a conclusion that delusions and hallucinations are not separate symptoms but are adjoining parts of the continua. Closeness and overlapping of delusions and hallucinations might appear as a phenomenon known as "delusional perception" and some authors do not support the idea that delusions and hallucinations are static symptoms of an illness episode.

CONCLUSIONS

The origin of delusions according to the studies showed in this paper is heterogenous. The connection between delusions and abnormal function of anatomic brain structures or abnormal chemical changes responsible for neurotransmission seems to be obvious if we think of psychosis caused by brain injury, intoxication, infection or somatic disorders.

If we think of the brain as a whole it is clear that changes in one structure of the brain cause dysfunctions in other structures. The result of such a change is not only lack of one function but also the occurrence of other abnormal functions which can happen very fast. What is more, such structural change may result in disclosure of neuronal function of distant or close brain structures which were unused till the time of damage.

There is a view that delusions theories which concentrate on single brain injury are insufficient since primary and secondary changes cannot be clearly distinguished. Such theories describe reasons of delusions as anatomical and physiological changes and do not mention psychological or social aspects. It seems that a model based on the assumption that physiological processes are organizing and are responsible for activity of brain structures and that there is a connection between emotional experiences and mental disorders would be more appropriate.

REFERENCES

1. Beckman H.: Developmental malformations in cerebral structures of schizophrenic patients. Eur. Arch. Psychiatry Clin. Neurosci., 249 (suppl. 4), 44, 1999.

2. Buchanan R.W., Carpenter W.T. jr.: The neuroanatomies of schizophrenia. Schizophrenia Bulletin, 23, 3, 367, 1997.
3. Chee M.W.L. et al.: Auditory and visual word processing studied with f MRI, Human Brain Mapping, 7, 15 ,1999.
4. Chua S.E., McKenna P.J.: Schizophrenia – a brain disease? A critical review of structural cerebral abnormality in the disorder. Br. J. Psychiatry, 166, 563, 1995
5. David A.S., Howard R.: An experimental phenomenological approach to delusional memory in schizophrenia and late paraphrenia. Psychological Medicine, 24, 515, 1994.
6. De Lisi L.E. et al.: Brain morphology in first-episode schizophrenic-like psychotic patients: a quantitative magnetic resonance imaging study. Biol. Psychiat., 29, 159, 1991.
7. Gray J.A.: Integrating schizophrenia. Schizophrenia Bulletin, 24, 2, 249, 1998
8. Grzywa A.: Omamy i urojenia. Urban & Partner, Wrocław 2000.
9. Harvey I. et al.: Reduction in cortical volume in schizophrenia on magnetic resonance imaging. Psychol. Med., 23, 591, 1993.
10. Howes O.D. et al.: Pathways to schizophrenia: the impact of environmental factors. Int. J. Neuropsychopharmacol. 7 Suppl. 1, 7, 2004
11. Jablensky A.V., Kalaydijeva L.V.: Genetic epidemiology of schizophrenia: Phenotypes, risk factors, and reproductive behavior. Am. J. Psychiatry, 160, 425, 2003
12. Johnstone E.C. et al.: Cerebral ventricular size and cognitive impairment in chronic schizophrenia. Lancet, 2, 924, 1976.
13. Kingsbourne M., Hicks R. E.: Mapping cerebral functional space. In: M. Kingsbourne (ed): The Asymmetrical Function of Brain. Cambridge University Press, New York 1978.
14. Levine D.N., Finkelstein S.: Delayed psychosis after right temporoparietal stroke or trauma: relation to epilepsy, Neurology, 32, 267, 1982.
15. Mojtabai R. et al..: Neuropsychological differences between first-admission schizophrenia and psychotic affective disorders. Am. J. Psychiatry, 157, 1453, 2000.
16. Selemon L.D., Goldman-Rakic G.: The reduced neuropil hypothesis: A circuit based model of schizophrenia. Biol. Psychiatry, 45, 17, 1999.
17. Van Os J. et al.: Strauss (1969) revisited: a psychosis continuum in the general population? Sch. Res., 45, 11, 2000.
18. Van Rijn S. et al.: Neurobiology of emotion and high risk for schizophrenia: role of the amygdala and the X-chromosome. Neuroscience and Biobehavioral Reviews, 29, 385, 2005.
19. Walker E.F. et al.: Childhood behavioral characteristics and adult brain morphology in schizophrenia. Schizophr. Res., 22, 93, 1996.
20. Weinberger D.R. et al.: Poor premorbid adjustment and CT scan abnormalities in chronic schizophrenia. Am. J. Psychiat., 137, 1410, 1980.

SUMMARY

Schizophrenia is a brain disease whose pathophysiology is still unknown despite intensive investigation. Many authors conduct studies in order to reveal the origin of this disease which would be helpful in treatment and preventing the illness. In this paper authors made a survey of papers concerning the connection between delusions and anatomical brain changes as well as psychological disorders resulting from such changes. There are two main trends of research conducted in order to find the origin of delusions in schizophrenia: the first is focused on primary detection of delusions and then searching for organic brain changes. Authors of the second trend affirm the presence of brain injury and afterwards are looking for delusions. An analysis of the literature allows to present conclusions as follows: the majority of authors say that delusions are connected with left hemisphere injuries since this part of the brain is responsible for cognitive and linguistic processes, whereas the right hemisphere is accountable for visual-spatial processes and nonverbal learning. Dysfunctions of subcortex nuclei or the limbic system might lead to occurrence of strong emotions which may result in disorders of healthy hemisphere and as a

consequence of such a situation, delusions. There is a view that delusions theories which concentrate on single brain injury are insufficient since primary and secondary changes cannot be clearly distinguished. Such theories describe reasons of delusions as anatomical and physiological changes and do not mention psychological or social aspects. It seems that a model based on the assumption that physiological processes are organizing and are responsible for activity of brain structures and that there is a connection between emotional experiences and mental disorders would be more appropriate

Neuropsychologiczne podłoże urojeń

Schizofrenia jest chorobą mózgu, której patofizjologia, mimo intensywnych badań, dotychczas nie została wyjaśniona. Wielu autorów prowadzi badania mające na celu poznanie genezy schizofrenii, co w znacznym stopniu ułatwiłoby leczenie, a przede wszystkim mogłoby dać szansę na skuteczną prewencję zachorowań na tę chorobę. W pracy dokonano przeglądu piśmiennictwa dotyczącego związku urojeń ze zmianami neuropatologicznymi i wynikającymi z nich zaburzeniami funkcji psychologicznych. Prace analizujące powstawanie urojeń w przebiegu schizofrenii można podzielić na dwa nurty. Pierwszy z nich polega na pierwotnym stwierdzeniu urojeń i wtórnym poszukiwaniu ich organicznego uwarunkowania. Autorzy drugiego nurtu najpierw potwierdzają organiczne uszkodzenie, a w dalszej kolejności poszukują zaburzeń treści myślenia, jakimi są urojenia. Po analizie literatury, w której reprezentowane są obydwa nurty, można postawić następujące wnioski. Według większości badaczy urojenia są związane z uszkodzeniem półkuli lewej, ponieważ to ona odpowiada za procesy poznawczo-językowe, podczas gdy procesy wzrokowo-przestrzenne i uczenie się są powiązane z półkulą prawą. W stanach chorobowych dysfunkcje jąder podkorowych czy też układu limbicznego mogą prowadzić do powstawania silnych emocji, co może skutkować zaburzeniami nienaruszonej półkuli, a w konsekwencji powstaniem urojeń. Wielu autorów sugeruje, że teorie poszukujące przyczyny urojeń w uszkodzeniu jakiegoś jednego miejsca mózgu nie są wystarczające, ponieważ nie pozwalają odróżnić zaburzenia pierwotnego od wtórnych. Teorie te lokalizują patogenezę choroby na poziomie anatomicznym i fizjologicznym, nie biorąc pod uwagę aspektów psychologicznych i społecznych. Wydaje się jednak, że należałoby brać pod uwagę model oparty na założeniu, iż procesy fizjologiczne organizują poszczególne obszary mózgu oraz że istnieje ścisły związek pomiędzy przeżyciami emocjonalnymi a zaburzeniami psychicznymi.