Neurodegenerative Diseases: Current Research
Volume 2 (2022) 3 Pages
DOI: https://dx.doi.org/10.53043/NDCR-2-005

Review Article | Open Access

Brain-heart Connections in Spinocerebellar Ataxia: Role of Central Autonomic Network

Dibashree Tamuli[1,2], Kishore K. Deepak[2*]

[1]Department of Zoology, Nalbari College, Assam
[2]Department of Physiology, All India Institute of Medical Sciences, New Delhi, India

***Correspondence:** Prof. K. K. Deepak, MD, PhD, FAMS, DSc, Head, Department of Physiology, Room no. 2009, Teaching Block, Second Floor, New Delhi-110029; Tel: (O) 0091-11-2659 3583, (R) 011 2658 8342; Mob: 8826168442, 9868397129

Received: June 27, 2022;

Accepted: July 05, 2022;

Published: July 07, 2022

Citation: Dibashree Tamuli, Kishore K. Deepak. Brain-heart Connections in Spinocerebellar Ataxia: Role of Central Autonomic Network. Neurodegener Dis Current Res. (2022);2(1): 1-3

Key words: Central autonomic network, autonomic function, spinocerebellar ataxia, correlation

1. Abstact

More than a century ago, C. Bernard stated the connection between the brain and the heart. Here, we have emphasized on the central autonomic network (CAN) based on our previous pioneering work of structure-function connectivity in spinocerebellar ataxia (SCA) patients. In order to study the correlation, SCA was the suitable disease model as being neurodegenerative disorder with fequent autonomic manifestations. The prefrontal cortex, bilateral middle temporal, left cuneus, left lingual and left caudate were the key brain areas of CAN for top down regulation of autonomic function assessed as heart rate variability and severity scoring. We have evaluated CAN to know parasympathetic and sympathetic autonomic brain areas vis-a-vis parasympathetic and sympathetic autonomic function in SCA which may shed light on putative pathophysiology.

Central autonomic network (CAN) is the internal regulatory system which controls and coordinates the autonomic nervous system. Animal experimental studies have revealed the cortical and subcortical areas of CAN comprised of insular cortex, hypothalamus, amygdala, parabrachial complex, periaqueductal gray, nucleus of tractus solitarius and ventrolateral medulla [1-3].

Yet with the advancement of neuroimaging techniques, the studies intriguing CAN were performed in human [6]. By the task based activation method of autonomic control, a large number of studies have found the areas of brain in autonomic control [17]. Althogh the autonomic nervous system regulates a wide range of physiological aspects in our body like – cardiovascular, respiratory, endocrine and digestive [4], amongst all, heart rate variability (HRV) has been widely used as cardiovascular autonomic marker to know the state of heart and brain as well [5-7]. The neuroimaging studies were performed to identify the brain areas associated with HRV revealed that insula, prefrontal and cingulate cortices were activated during autonomic task and thus, related to HRV [5,6,8].

In our earlier pioneering work, we have assessed a correlation between the brain areas and autonomic function parameters in spinocerebellar ataxia (SCA) patients [7]. To study this association, SCA disease model was found to be suitable as SCA being a neurodegenerative disorder with autonomic dysfunction. Our neuroimaging study revealed the cortical brain atrophy in all the four lobes (frontal, parietal, occipital and temporal) along with the volumetric loss in subcortical brain areas in SCA [9]. On the other hand, literature suggested 60% dysautonomia in SCA patients [10-12]. We have also reported autonomic dysfunction in SCA patients [13,14]. We more intrigued to know about the structural atrophy goes hand in hand with the loss of functional attributes of autonomic regulation in SCA patients.

Thus, in one hand, we had volume brain areas achieved by whole brain scanning and in other hand, we had autonomic parameters performed by comprehensive autonomic function tests. In order to correlate the structure-function parameters, we have selected the autonomic parameters such as HRV, being the commonly used cardiovascular parameter. While choosing other autonomic biomarkers, baroreflex sensitivity (BRS) has been used as surrogate marker for short term blood pressure regulation [14]. Actually, baroreflex lowers the blood pressure fluctuations by regulating the heart rate and vascular tone [15]. The modulation is occurred by the baroreflex arc in medulla along with the inputs from higher cortical and subcortical brain areas of CAN [7,14]. Nevertheless, composite autonomic severity score (CASS) is a comprehensive method to quantify autonomic function [16].

The strength lied in that we had able to differentiate the parasympathetic and sympathetic autonomic brain areas based on the correlation of parasympathetic and sympathetic autonomic correlates in the patients of SCA [14]. Priorly, *Beissner et al.* described the brain areas involved in parasympathetic and sympathetic autonomic control in their meta-analytic review based on activation likelihood method [17].

This structure-function comprehensive correlation approach is on priority for the understanding on the pathophysiology of autonomic abnormalities in SCA patients.

2. Brain structures associated with components of autonomic correlates in SCA

All the brain areas associated with the components of autonomic correlates were important parts of the CAN (Table 1). The common brain area associations were as follows:

Left cuneus which was usually correlated with HRV and systolic BRS may regulate parasympathetic component of BRS by regulating the response of heart rate in the SCA patients.

Similarly, left lingual, the common area associated with HRV and systolic BPV was responsible for parasympathetic modulation while left caudate, a significant area of association was related to both parasympathetic and sympathetic autonomic control.

The right lateral orbitofrontal cortex and bilateral medial orbitofrontal cortex, both were the part of prefrontal cortex, the area of sympathetic modulation. The prefrontal cortex was commonly connected between systolic BRS and systolic BPV.

Table 1: Correlation of brain areas with autonomic function parameters in SCA patients.

Brain areas	Autonomic correlates	Brain areas
Parasympathetic brain areas		**Sympathetic brain areas**
Left cuneus	HRV	Left lingual
Left middle temporal		Left accumbens
Right isthmus cingulate		Left hippocampus
Left caudate		Left caudate
Right cerebellar cortex		Right cerebellar cortex
Right temporal pole	Systolic BPV	Right lateral orbitofrontal cortex
Left caudate		
Left cuneus	Systolic BRS	Left lingual
Right cuneus		Bilateral medial orbitofrontal cortex
		Pars opecularis
		Right caudal anterior cingulate
		Left caudate
Bilateral middle temporal	CASS	Bilateral caudal middle frontal
		Pars orbitalis

Moreover, the prefrontal cortex (included bilateral caudal middle frontal, right lateral orbitofrontal cortex and bilateral medial orbitofrontal cortex) appeared as the connecting link between CASS and autonomic tone parameters in SCA reveals the associations of CAN and autonomic attributable [7].

3. Conclusion

The comprehensive assessment of autonomic dysfunction strongly appraised the top down regulation by the central autonomic network in SCA patients. Therefore, the holistic brain structure and autonomic function correlation study may provide the probable pathophysiological insight of dysautonomia in SCA patients.

4. Abbreviations

HRV- heart rate variability, BPV – blood pressure variability, BRS – baroreflex sensitivity, CASS – composite autonomic severity score

8. References

1. Benarroch EE. The central autonomic network: functional organization, dysfunction, and perspective. In Mayo Clinic Proceedings 1993 Oct 1 (Vol. 68, No. 10, pp. 988-1001).
2. Verberne AJ, Owens NC. Cortical modulation of the cardiovascular system. Progress in neurobiology. 1998 Feb 1;54(2):149-68.
3. Saper CB. The central autonomic nervous system: conscious visceral perception and autonomic pattern generation. Annual review of neuroscience. 2002; 25: 433.
4. Jänig W. Integrative action of the autonomic nervous system: Neurobiology of homeostasis. Cambridge University Press; 2008 Jun 26.
5. Napadow V, Dhond R, Conti G, Makris N, Brown EN, Barbieri R. Brain correlates of autonomic modulation: combining heart rate variability with fMRI. Neuroimage. 2008 Aug 1;42(1):169-77.
6. Thayer JF, Åhs F, Fredrikson M, Sollers III JJ, Wager TD. A meta-analysis of heart rate variability and neuroimaging studies: implications for heart rate variability as a marker of stress and health. Neuroscience & Biobehavioral Reviews. 2012 Feb 1;36(2):747-56.
7. Tamuli D, Kaur M, Jaryal AK, Srivastava AK, Kumaran SS, Deepak KK. Structural atrophy of central autonomic network correlates with the functional attributes of autonomic nervous system in spinocerebellar ataxia patients. Journal of Clinical Neuroscience. 2021a Nov 1; 93 :274-81.
8. Critchley HD, Mathias CJ, Josephs O, O'Doherty J, Zanini S, Dewar BK, Cipolotti L, Shallice T, Dolan RJ. Human cingulate cortex and autonomic control: converging neuroimaging and clinical evidence. Brain. 2003 Oct 1;126(10):2139-52.
9. Tamuli D, Kaur M, Sethi T, Singh A, Faruq M, Jaryal AK, Srivastava AK, Kumaran SS, Deepak KK. Cortical and subcortical brain area atrophy in SCA1 and SCA2 patients in India: the structural MRI underpinnings and correlative insight among the atrophy and disease attributes. Neurology India. 2021b Sep 1;69(5):1318.
10. Yeh TH, Lu CS, Chou YH, Chong CC, Wu T, Han NH, Chen RS. Autonomic dysfunction in Machado-Joseph disease. Archives of neurology. 2005 Apr 1;62(4):630-6.
11. Netravathi M, Sathyaprabha TN, Jayalaxmi K, Datta P, Nirmala M, Pal PK. A comparative study of cardiac dysautonomia in autosomal dominant spinocerebellar ataxias and idiopathic sporadic ataxias. Acta neurologica scandinavica. 2009 Sep;120(3):204-9.
12. Montes-Brown J, Sánchez-Cruz G, García AM, Báez ME, Velázquez-Pérez L. Heart rate variability in type 2 spinocerebellar ataxia. Acta neurologica scandinavica. 2010 Nov;122(5):329-35.
13. Tamuli D, Godiyal AK, Kaur M, Jaryal AK, Srivastava AK, Deepak KK. Autonomic function based classification of spinocerebellar ataxia type 1 and 2 using machine learning classifiers. Indian J Physiol Pharmacol. 2017;61(4):323-32.
14. Tamuli D, Kaur M, Boligarla A, Jaryal AK, Srivastava AK, Deepak KK. Depressed baroreflex sensitivity from spontaneous oscillations of heart rate and blood pressure in SCA1 and SCA2. Acta Neurologica Scandinavica. 2019 Nov;140(5):350-8.
15. Guyton AC, Hall JE. Textbook of medical physiology. Philadelphia: Saunders; 1986 Sep 20.
16. Novak P. Quantitative autonomic testing. JoVE (Journal of Visualized Experiments). 2011 Jul 19(53): e2502.
17. Beissner F, Meissner K, Bär KJ, Napadow V. The autonomic brain: an activation likelihood estimation meta-analysis for central processing of autonomic function. Journal of neuroscience. 2013 Jun 19;33(25):10503-11.