International Research Journal of Natural and Applied Sciences
Vol. 4, Issue 2, February 2017 Impact Factor- 5.46
ISSN: (2349-4077)

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ASSOCIATION BETWEEN VERTEBRAL ARTERY BLOOD FLOW AND CERVICAL VERTIGO

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ABSTRACT

The vertebrobasilar artery has a major role in the blood supply to the brain along with the internal carotid artery as it carries 20% of the blood to the brain forming a posterior system. Studies have shown that the position of vertebral artery has a role to play in the cervical vertigo. As the vertebral artery enters the foramen magnum via the transverse foramen c2 vertebra which again bends upwards before reaching the transverse foramen of the atlas (C1 vertebra), thus showing the direct relationship of cervical spine and vertebral artery so cervical dysfunctions can lead to change in the hemodynamic status of the vertebral artery .So Differential diagnosis for distinguishing the exact causes for the cervical vertigo or dizziness should be done and thereafter the manual therapeutic approach should be directed towards the measures which can directly or indirectly show the improvement in the symptoms like dizziness/vertigo, lightheadedness caused alteration in the flow of vertebral artery.

Key Words: Vertebral artery, Cervical vertigo, Dizziness, Manual therapy.

Introduction

The blood supply to the brain is majorly from two arterial systems – the internal carotid arteries which lies anteriorly and vertebrobasilar system posteriorly . The internal carotid arteries carry around 80% of blood to the brain as compared to 20% by the vertebrobasilar system posterior system. The ICA at the level of cervical third (c3) vertebra bifurcate from common carotid artery and runs through the contractile structures such as the sternocleidomastoid, longus- capitis,

stylohyoid, omohyoid, and diagastric muscles to reach at the level of c1 verterbra(first vertebra) and then enter into skull from carotid canal of temporal bone and at last to join the Circle of Willis.

The posterior vertebrobasilar system include both vertebral artery(right and left) which passes through the transverse processes of cervical vertebrae. Cagnie, B 2005 stated about vertebral artery segments .It has prevertebral segment originated from the subclavian artery traverses the subclavian triangle then passes lateral to the longus colli muscle and medial to the scalenus anterior muscle to enter the C6 cervical transverse foramen. Here it is surrounded by the cervical sympathetic plexus and two vertebral veins. From c6 vertebra to the c3 cervical vertebra ,the vertebral artery remain tightly into the transverse foramina .This vertebral segment of artery is associated with vertebral venous plexus and a plexus of sympathetic nerve fibers of cervical ganglia. Here the artery is closely related with uncinate processes of each vertebral body(medially) and ventral rami of the cervical nerves(posteriorly). From c3 cervical vertebra ,the third segment of vertebral artery starts and takes a more lateral course to reach the transverse foramen of the axis (c2 vertebra) and again bend upward before reaching the transverse foramen of the atlas(c1 vertebra).After this ,it passes deep to the obliqus capitis inferior muscle moving medial to the lateral aspect of the superior articular process of the atlas and reaches to groove on the upper surface of the posterior arch of the atlas where it is loosely connected to the capsule of the atlanto-occipital joint. It travels medially with the atlanto-occipital membrane and enters the cranial cavity through the foramen magnum where the artery gives rise to three branches, the posterior spinal artery, anterior spinal artery, and posterior inferior cerebellar artery before joining the basillary artery then it feeds into the circle of willis. The vertebro-basillary system supplies the spinal cord, brain stem, Medulla Oblongata, Pons, cerebellum, the inferior and posterior parts of the cerebrum (occipital and temporal lobes and Vestibular apparatus) . There is direct and intimate relationship between cervical spine and vertebral artery so it can be damaged with manipulation of the neck. Literature suggests that end-range rotation and extension of cervical spine is the most stressful position for the suboccipital part of the vertebral artery to compress ipsilaterally or stretched contralaterally to movement and lead to reduced blood flow in arteries. It is observed that blood flow below the threshold level required for adequate oxygen delivery, causes compromised cerebral perfusion, hypoxia and neuronal dysfunction and can be clinical manifestated by various signs and symptoms including dizziness, syncope and unconsciousness, respiratory and cardiac irregularities, auditory and

visual disturbances, paresis and paralysis of muscles (Jeanette Mitchell, 2005). These all symptoms are categorized into one common term called vertebra-basillary insufficiency which means temporary or permanent reduction or suspension of blood supply to the hind brain through the right and left vertebral arteries and the basilar artery *(Rivett DA., 2005).*

The term "Cervical vertigo was first coined by Ryan and Cope in 1955 and is defined as a vertigo of cervical origin which can be elicited by changes in the position of the neck (Luxon, 1984 and Oostendorp et al 1992).It is commonly associated with whiplash injury. Wrisley in 2000 reported that the incidence of symptoms of dizziness or vertigo in whiplash patients are 20–58%.

Clinical Aspects of Vertigo

Vertigo is the most frequent type of dizziness and is characterized by either an illusory perception of a movement of the body (spinning) and/or of the surroundings or an unpleasant disturbance of spatial orientation. The causes associated with vertigo can be central and peripheral. The central causes of vertigo includes arterio venous malfunction, wallenbergs syndrome, cerebral haemorrhage, brain stem vascular disease, cerebro medullary junction malfunctions, multiple sclerosis, tumors of brain stem, arnold chiari malfunctions, demyelinating diseases, cerebellum meningioma, and metastatic tumor .The peripheral causes of vertigo include conditions like Bppv, direct trauma to semicircular canals or its infection, semicircular canal water penetration, semicircular canal dehiscence syndrome, cervicogenic vertigo, labyrinthitis, meniere's syndrome, non supportive diseases of labyrinth (Hain, T.C., 2015)

Researchers also mentioned some rare causes of vertigo includes perilymphatics fistula, cholesteatoma erosion, otosclerosis, cerebellopontine angle tumor and herpes zoster oticus . Hanley, K 2001 .Vertigo may also be associated with certain other conditions like cardiac arrhymias, severe anemia, orthostatic hypotension, exogenous intoxications, drugs and alcohol pshycogenic vertigo(Hain, T.C., 2015). The causes of vertigo and other related symptoms can also result from internal vascular compression of vertebral artery like atherosclerosis, arterial dissection or a thromboembolus as well as from external factors like mechanical compression from hypertonic musculature, cervical fracture, osteophytes, or dislocation and head posture (Huijbregts and Vidal 2004).Vertigo resulting from cervical pathologies was first described in 1858 by claude bernad. Vertebro-basillary insufficiency encompasses a wide spectrum of

rotational hemodynamic insufficiency that might result from degenerative cervical spine changes (Vates, et al,2002) and cervical manipulation (Albuquerque,Hu,Dashti ,2011).

Prevalence of vertigo

The vertigo can be evaluated under various specialities medicine, cardiology, neurology, psychiatry because of different multiple etiologies. In a survey by department of ENT at Post-Graduate Institute of Medical Education and Research,Chandigarh in urban population in the Union Territory of Chandigarh, Raman Arbol 1992 stated that cardiovascular disease comes on first rank in showing vertigo 0.32% as compared to patients having neurologic disease carrying prevanlence rate of 0.14% in general population in which commonest cause was cervical spondylosis . Only 0.09% population having vertigo is due to metabolic disorders in which primarily diabetes mellitus was leading cause and other is hypothyroidism (2.8%).Benign positional paroxysmal vertigo was found in 7% of population selected and there was less occurrence of meniere's disease. The study also mentioned one miscellaneous group which shows signs of vertigo because of psychogenic reasons(4.2%).

Pathophysiology of vertigo

Vertigo includes various multisensory and sensorimotor syndromes of different etiologies and pathogeneses (Domenico plantone et al 2013). According to Yacovino & Hain (2013), roughly 50% of patients who are referred for dizziness have vertigo. Among the various causes of cervical vertigo, basically due to neck disorders, has been the most controversial. The various neck structures like cervical afferents, carotid sinuses, muscles, carotid and vertebral arteries are involved in balance control, vascular tone control, support of the cervical spinal cord, cardiovascular control and blood circulation respectively (Thomas 2013). The symptoms such as dizziness, imbalance, or vertigo associated with cervicocephalic movements could also be attributed to vestibular (inner ear), visual, vascular, neurovascular, cervicoproprioceptive, or cervical spinal cord dysfunction. The vertigo associated with condition called Benign positional vertigo are intermittent and depending upon positioning of head with respect to gravity. BPPV vertigo occurs along with nystagmus .The characteristics of symptoms depend upon type of BPPV either posterior canal, horizontal canal or rarely anterior canal. The cause of BPPV is idiopathic but it may be secondary to inner ear disease like vestibular neuritis, labyrinthitis and meniere disease or damage in the inner ear thus detaching otolith from utricular macule. The

detached debris can free float in the semicircular canal (canalolisthiasis) or may attached to the cupula(cupulolithiasis). The gold standard test for diagnosing the condition is Dix-Hallpike maneuver for posterior BPPV and supine roll test for Horizontal BPPV.(Seung-Han Lee et al 2010).

A minority of cases have vertigo along with marked nausea ,vomiting and unsteadiness occur in young or middle aged adults are because of vestibular neuronitis (cooper 1993). The cause is the degeneration of the vestibular nerve or its connections. Another dysfunction relates vertigo is meniere disease first described by Prosper Ménière in 1861 as the triad of fluctuating hearing loss, tinnitus, and episodic vertigo along with the sensation of fullness or pressure in the ear. According to postmortem studies in 1938 increase of pressure within semicircular canal is the main pathology lies in meniere disease. Various predisposing factors are viral infection, vascular or genetic factor thus have familial predisposition also. The episode of vertigo last for hours along with feeling of nausea, tinnitus and rotational nystagmus different from BPPV. The disease is diagnosed with audiometric test by ENT specialist and can be relieved in the short term with the use of betahistine drug. The cause of vertigo may be of vascular origin where the blood supply to the brain stem is reduced through vertebra-basillary system. Inadequate blood flow through one of the vertebral artery will not produce symptoms unless there is scarce of blood flow in the terminal vessels or until there is marked reduction of blood flow in collateral circulation.The disturbance in the blood supply to the vestibulocochlear organ is due to impairment of vertebral artery blood flow provoked by degeneration of cervical spine (Miyagami and Sullivan et al 1975). In cervical dysfunction, the symptoms may arise in neutral position of cervical spine or arise with change of position.(Mapstone and Spetzler 1982). Grad (1989) reported that approximately 20% of Vertebrabasillary artery insufficient patients had experienced vertigo once earlier. Head rotation can outbreak VB Symptom in beauty parlour stroke (Foye, 2002) ,bow hunter stroke (NEVINS, 1961) and in power syndromes but some cases are also seen where head rotation will not cause any symptoms(Faris et al 1963).

Literature shows that the pathogenesis of cervical spondylosis leading to vertigo is quite complex. There are various theories associated with vertigo and cervical spinal dysfunction-

(a) Neurogenic theory

In cervical spondylosis, changes in the cervical afferent flow may occur because of the pressure on the cervical nerve roots caused by disc protrusions. (Wilkinson 1970). Unstable vestibular tone are caused by these abnormal afferent flow in the posterior cervical nerves to the vestibular

nuclei, which is further upset by neck torsion. (Mangat and McDowall 1973). Upper cervical somatosensory input is altered by neck tenderness and limitation of movement which are common findings in cervical spondylosis. Thus, if proprioceptors in the cervical musculature or in the apophysial joints are disrupted, this may lead to distortion of the normal input to the vestibular nuclei. (Brandt and Bronstein 2001). The assumption that neck proprioception has great importance for postural control is supported strongly by DeJong and DeJong in 1977 who investigated after injecting local anesthetics into their own necks. There was dizziness and unsteadiness after administration of injections. Disturbance in cervical sensory input cause dys-regulation of postural mechanism and multiplicity of muscle spindles in the deep short intervertebral neck muscles receptor nerve endings in the cervical spine. Longet (1845) noted disturbance of gait in animals if there is disturbed supply to the upper cervical sensors through neck muscles. Abrahams and falchetto (1969) and Richmond (1976) also found the similar result of getting unsteadiness after cutting the upper cervical dorsal roots in animals. Koskimies et al 1997 reported that subjects having "tension neck" had more deviation with respect to their posture which is initiated by vibration of their neck than persons without a stiff neck and this might be the reason for vertigo. In other words, there is increase input received from proprioceptors if the neck muscles are tight and hence dizziness can also be more felt. Magnussen et al 2006 reported in a similar fashion that there is dominancy of cervical input during neck pain or stiffness over vestibular input because of more activation of neck muscles. Same response can be seen in the patients after whiplash injury who had paucity in reproducing neck position (Loudon et al 1997).

(b) Vasogenic theory

The vertebrobasilar system gives blood stock to vestibular labyrinth, VIII nerve, brain stem, cerebellum and occipital lobes . (Mahoney 1997). Cervical osteophytes can put pressure on the vertebral artery during head turning to same or opposite side and occlude the blood flow which further decrease the arterial supply of vestibulocochlear organ (Strek et al 1998). As the blood supply to vestibulocochlear organ is totally dependent on vertebrobasilar circulation hence causes vertigo. (Brandt and Baloh 2005). Morinaka and associates stated that this relationship between cervical proprioception and vestibular nuclei can lead to a vicious cycle of imbalance and muscle spasm or contracture thus increases the symptoms (Yacovino et al 2013) .Travell and Simons in 1983 have also confirmed that trigger points of upper fibers of the trapezius

muscle and the clavicular division of the sternocleidomastoid can build up the symptoms of momentary dizziness and spatial disorientation. However, it is difficult to show this relation in an experimental study.The theory that cervical nystagmus and vertigo are caused by an alteration of the function of somatic neck afferents in humans is supported by strong indirect evidence as far as the present state of knowledge is concerned (Yacovino et al 2013) Moreover, Brown et al 2002 proved that the spasm or contracture of the sternocleidomastoid and upper trapezius muscles might initiate erratic muscular-sensory information.

Clinical Diagnostic criteria

Due to multi-causative etiology of vertigo, it is not possible to evaluate the patient at one platform. The duration of the vertigo attack is of paramount importance. Meniere's disease causes vertigo attacks lasting hours while vertigo that develops in a period of hours and slowly resolves over a period of days or weeks is more probably due to vestibular neuronitis and labyrinthis (Domenico at al 2013).The episodes of vestibular associated migraine and vertebrobasilar insufficiency typically last minutes. Benign Paroxysmal positional vertigo (BPPV) is associated with a duration of seconds and with head movements in relation to gravity. The most useful diagnostic tests to correctly differentiate the different forms of vertigo are Dix-Hallpike maneuver, Head impulse test and electronystamography. Head impulse test detects unilateral or bilateral vestibular hypofunction through the vestibulo-ocular reflex response (Maranhao and Maranhao-Filho,2012). The Dix-Hallpike maneuver is useful for the diagnosis of BPPV.(Dix and Hallpike 1952) albeit it should be remembered that the sensitivity of this test for BPPV is 79% and the specificity is 75%. (Hain, 2015). The combination of cervical pain and vertigo caused by cephalic rotation as the only diagnostic criterion for cervical vertigo as proposed by Yahia et al. The Vertebral artery test is the commonly used test to screen for VBI before performing high velocity thrust (HVT) and Non-HVT techniques (Furman&Cass,1996; Tusa and Schubert,2007; Fife et al 2008). The ending positions of the Hallpike-Dix test and VAT are similar which induce dizziness so it is necessary to differentially diagnose both conditions. To futherance the differential diagnostic process of dizzy patients , a modified VAT(mVAT) has been described in the literature which can be is performed in sitting versus supine(Clendaniel and Landel,2007).The mVAT minimizes angular position changes of the inner ear and dizziness attributed to BPPV is less likely to be provoked. Cervical vertigo is intensify by movements of

neck and associated with neck pain .thus relief of dizziness oftentimes occurs with relief of neck pain(*Wrisley and Bracher 2000)*

For the diagnosis of the hemo-dynamic status in vertebraobasillary artery system, techniques like magnetic resonance angiography, digital subtraction angiography, invasive electromagnetic flow meter (EMF) and color Doppler Ultrasound (CDU) are used. Currently Color Doppler ultrasonography is the first choice in the examination of the extracranial part of vertebral artery because it is noninvasive, cheap, easy to apply, and repeatable (Ozdemir, et al 2005) .The Doppler ultrasound, a non-invasive ultrasonic procedure, is commonly used to determine whether blood flow through the vertebral and carotid arteries is compromised. Doppler ultrasound has become the primary investigative tool used to evaluate in vivo the validity of pre-manipulative tests primarily by determining the effects of cervical spine rotation and/or extension on various VA blood flow parameters. Sterk et al in 1998 stated that low values of vertebral artery blood flow velocity was present in 41% of the patients with tinnitus, vertigo, or degenerative cervical pathology. Machaly and associates in 2011 also reported significantly reduced blood flow as well as a higher prevalence of degenerative osteoarticular changes in patients with vertigo (71%) compared with those without vertigo (33%). (Strek et al 1998) whereas Bayrak et al 2009 found no considerable changes in vertebral artery flow in neutral position on doppler measurements of 91 patients with radiologically confirmed cervical degenerative changes. In summary there is lacking of standardized method of testing the cervical vertigo. Vestibular test are helpful for diagnosing inner ear dysfunctions, history and radiographic studies are helpful in detecting the structural cause of vertigo. Thus the patients are having vertigo without a proof or after excluding the other diagnosis are considered in the category of cervical vertigo.

Management

The treatment decisions are made according to evidence based practice in clinical setting. As said by Sackett et al there are three basic components which combine together for deciding treatment strategies. First the clinical expertise of the practitioner, second guidance from the best available evidence from systematic research; and, notably and third the individual patient's circumstances. The accurate management is directed by patient's presentation of symptoms.Because of the multi-causative etiology of vertigo, patients seek their treatment with various specialities like medicine, cardiology, orthopedic surgery, neurosurgery, gynecology,

psychiatry etc. Modern technique in surgery or drug can be introduced to get relief from vertigo. Betahistine is a extensively used drug to manage vertigo. Some of the studies showed that betahistine does relief in vertigo symptoms by improving the cochlear microcirculation , increases the cerebral blood flow and also reduces firing activity of lateral vestibular nucleus neurons.(Krishna et al 2000). A variety of other drugs like benzodiazepines, histaminergic agents, sympathomimetics and calcium antagonists are also used for the treatment of vertigo but their mechanism of action is poorly understood.(Olivier et al 1995).These drugs causes various adverse effects like upper gastrointestinal effects , headache and respiratory distress as reported by various studies (Conraux 1988; Duphar 1997; Mira 2003;Otto 2008). Physical therapy is also recommended for cervical vertigo **.V**arious physical therapy methods have a proven pain-relieving effect have been used in the rehabilitation process ed**.** In some study it can also be combined with medication to relive pain and reduce muscle spasm associated with cervical vertigo. Various Physical therapy intervention may include cervical mobilization, exercise, maintaining good posture (Karlberg et al 1996) . Some study given neck traction to patients. The prognosis is good, approx 75% of patients treated have improvement of symptoms. Manual therapy has been shown to have greater impact on cervical vertigo (Lystad et al, 2011) .Krauss et.al. 2008 have described translatoric spinal manipulation (TSM) techniques alternative to rotatory manipulation because it is safe for patients in terms that it does not affect the vertebral artery as these manipulations are small- amplitude manipulative techniques using straight-line impulses executed in either parallel or perpendicular fashion to facet joints of vertebral motion segment. But Kondratek et al in 2011 found no significant difference with the baseline values taken in neutral position of cervical spine and analyzing VA blood flow during translatoric non-thrust techniques given at C1-C2 and C5-C6 . Lu et al in 1996 conferred a series of nine case studies who had rotational vertebral artery syndrome and concluded that osteophytes are the main cause of artery compression at first cervical vertebra (44%) and shown the complete disappearance of symptoms after surgical decompression despite 11% of patient showed instability of cervical spine postsurgically.

Concerning to the management of proprioceptive cervical vertigo,the quality of published studies in current literature is not good enough. Furman and cass(1996) suggested that there can be improvement in patients symptoms after vestibular rehabilitation when combined with manual therapy .In nearly the same way Karlberg 1996 and Reid 2005 concluded that physiotherapy shows effective role in treating the vertigo and cervicogenic dizziness symptoms.

In BPPV which is the most common otologic disorder,manual positional maneuvers are cost effective and successful procedure of managing the symptoms in these patients. (Hilton and Pinder 2003).The vertigo induced after whiplash injury effects ligaments, muscles and tendon etc of cervical spine where the pharmacological treatment and passive mobilizations are effective in reducing the pain and spasm. Jansen, G.B et al 2008 discourage the use of cervical collar which the other studies emphasize to avoid the movement of neck and thus reducing the vertigo symptoms. Very little research exist to evaluate the cervical vertigo. The clinical researches on cervical vertigo have uncertainity in confirming the clinical as well as laboratory diagnosis. The management of cervical vertigo is same as cervical pain syndrome. (Brandt, T. and Bronstein, A.M., 2001) where the focus area of treatment is cervical spine and cervical portion of vertebral artery. Decompression of vertebral artery by minor surgery at osteophyte level has been previously inked for relief of symptoms (Bakay and leslie 1965). Such treatment give exemplary relief of symptoms also provide satisfactory results to the patients.(Smith et al 1971). Patients showing sign and symptoms of VBI may have inadequate collateral circulation or vascular pathology negotiating blood flow in vertebral artery. Various mobilization and manipulation of cervical spine improve the functional status of the patient by decreasing the symptoms of vertigo but still there is need of the research which can analyse the change of hemodynamic parameters of vertebral artery by providing physiotherapeutic measures. Knowledge about the effect of cervical mobilization and vertebral artery blood flow may assist physiotherapist to design various exercise protocol for vertigo patients and help in avoiding potentially unsound or unsafe practices.

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