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GYRO-KNIFE

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1. INTRODUCTION

Radiosurgery has become an important treatment alternative to surgery for a variety of intracranial lesions. It has replaced surgery in some instances, complements surgery as postoperative adjunct in others, and most commonly represents an alternative to surgery or is the only treatment option.[i]

Radiosurgery, a term and method introduced by Lars Leksell in 1951, refers to single fraction, high dose irradiation of a limited target volume of tissue.[ii] Leksell's initial efforts were directed toward developing a method for using noninvasive technique in functional radiosurgery. These efforts used an orthovoltage x-ray tube attached to a stereotactic frame to produce converging beams which intersected at the treatment target. In 1968, the first gamma knife unit was installed in Stockholm, Sweden to treat patients with neurological functional disorders, brain tumors, and arteriovenous malformations.[iii] In 1980s, two additional units based on this design were installed in Buenos Aires, Argentina and in Sheffield, England. The fifth device was the first manufactured by Elekta Instruments (Stockholm, Sweden) and was installed at the University of Pittsburgh Hospital. A total of 91 Leksell Gamma Knife® units were operational in 1998.[iv]

LINAC is another type of radiosurgery which utilized a linear accelerator. It was developed at the University of Florida College of Medicine and introduced by Betti and Colombo in the mid 1980's. High energy, narrowly focused beams of x-rays are employed in this system. This system differs from Gamma Knife in the way the radiation beams are delivered to the patient's head. A stereotactic device is used to provide a geometric-coordinate reference but the radiation beams are emitted by a single source, which rotates slowly around the patient's head.[v] Linear accelerators varied each with their own specifications, which differed with respect to important variables such as monitors units, gantry sag, and collimation systems.[i]

The basic design and concept of gamma knife was not modified until 1996 when a new gamma rotating knife was designed by OUR New Medical Technology Development Co. Ltd. of Shenzen, P. R. China, and manufactured in France (Shenzen OUR International Technology and Science Co. Ltd. Shenzen , P.R. China). The OUR Rotating Gamma System (RGS) was first installed in September 1996.[iv] The FDA 510(k) marketing clearance for Rotating Gamma System in the United States was obtained in May 1997. All new machines are currently manufactured in Pleasanton, CA.[iv] After further refinement to accommodate technology advances, American Radiosurgery, Inc. introduced the Rotating Gamma System GammaART-6000™ in 2000. The Rotating Gamma System GammaART-6000™ has received special FDA 510(k) marketing clearance on April 2006.

The advantages of Rotating Gamma System GammaART-6000 as compared to the stationary gamma-based system are as follows;[vi]

- Equivalent geometrical accuracy

- Simultaneous rotation of source body, primary collimators and secondary collimators requires a smaller number of radiation sources
- Since the beams converge from a greater solid angle, the dose to normal tissue is spread over a greater volume, thus reduced radiation exposure to critical organs during treatment
- No radiation exposure when the patient is out of treatment position-improved radiation shielding to patient and staff, no transit dose
- Interior design provides a larger treatment volume-patients can be treated up to 3 cm more caudally-than the Gamma Knife
- Secondary collimators are built in-no helmet changing required
- 30 vs 201 Cobalt-60 sources means substantially lower loading/reloading cost and downtime

In 2004, Gamma Star Technology Development Co. Ltd. in Shanghai, China developed Gyro Rotating Gamma Radiotherapy System (Gyro-Knife) which integrated the functions of LINAC and traditional Gamma Knife.

Recently the Ministry of Tourism Malaysia informed the Ministry of Health Malaysia on the intention of Shanghai Heidelberg International Co. Ltd to start Gyro-knife service in Palm Resort Wellness Zone, Port Dickson. This technology review was carried out as an input for the proposed project.

2. OBJECTIVE/ OBJECTIVES

To determine the safety, effectiveness and cost effectiveness of Gyro Rotating Gamma radiotherapy system (Gyro – Knife) for cancer treatment.

3. TECHNICAL FEATURES

Gyro Rotating Gamma Radiotherapy System (known as Gyro-Knife) is the latest multi-functional radiotherapy system and referred as the fifth generation Gamma Knife.[vii] It was developed by Mr Song Shipeng from Gamma Star Technology Development Co. Ltd., Shanghai in 2004.[viii] According to the manufacturer, Gyro-Knife combined the functions of Linac and traditional Gamma Knife. It integrates Medical Imaging, Thermo Sensitization and Auto Breath Tracking technologies.[ix] It has integrated the merit of linear accelerator and gamma knife and realizes triple focusing innovatively. It adopts the principle of space gyro apparatus, installing the Co-60 focus radioactive source to the structure of two vertical gyro rotating. So it is also called "Gyro-Knife".

Gyro-Knife is claimed as not only able to do accurate neurosurgery operations as Cephalic Gamma Knife, but also able to carry out large range radiotherapy treatment as the existing most precise microbeam radiation therapy (MRT). It is able to radiate at different field diameters and different radiation duration, in which two parameters can be combined to shoot 3D image of a person. Gyro-Knife applied the unique Gyro- Rotating-Thrice-Focusing technology and thus greatly lightened the weight of the machine. Under the preconditioned that dose on smallest focus is guaranteed, the irradiation field diameter at the concentricity can range from 3.5 mm to a maximum of 50 mm.[ix]

As a result of the Gyro-Rotating-Thrice-Focusing technology, Gyro-Knife is able to deliver a higher focus-skin dose ratio which refers to the amount of dosage focused on the tumour compared to the dosage that affects the skin. Gyro-Knife has achieved a 550:1 ratio in comparison to the 10:1, 15:1, 50;1, 200:1 ratios of previous models. This indicate that it cause less damage to the skin and tissues surrounding the tumour, allowing for treatment on complicated cases such as brain tumors with little or no side effects.[7]

The Automatic Breath Tracking System track movements from patient's breathing and take that into account while administering treatment to ensure the target sites receives the full dosage and prevents damage to the healthy cells.[vii]

The Gyro-Knife has self shielding design which prevents any leakage of gamma radiation.[vii]

4. METHODOLOGY

4.1 SEARCH METHODS

Electronic databases were searched, which included Pubmed, OVID, Cochrane Reviews, EBM Reviews for controlled trials, Science Direct, Springer Link, FDA website from 2000-2007, MHRA (EU Medicines and Healthcare Products Regulatory Agency, CADTH : New and Emerging Health Technology Reports (Ontario), Horizon Scan and Google and Yahoo for published reports. Information also gathered through personal communication with local experts and the manufacturer.

The search strategy used the terms, which are either used singly or in various combinations: Gyro-knife, 5th Generation gamma knife, Latest gamma knife, Digital Co-60 Radiotherapy System, Radiosurgery, Rotating gamma knife, accuracy, effectiveness OR efficacy, safety OR safe OR "adverse effect*" OR "harm* effect*" OR toxicity, "cost effectiveness" OR "cost analysis" OR econom*. There were no limitations in the search.

4.2 SELECTION OF STUDIES

All published articles related to safety, efficacy / effectiveness and cost effectiveness of Gyro-knife for treatment of cancer were included in the study.

5. RESULTS AND DISCUSSION

5.1 SAFETY

There was no retrievable evidence found on the safety aspect of this technology. The manufacturer claimed that the Gyro-knife is currently recognized and certified in the US and China. However , evidence of US FDA approval could not be retrieved.[7] The China SFDA registration certificate is as attached in Appendix 1. This technology uses Cobalt 60 sources and therefore issues regarding the handling and disposal of the radioactive waste must be taken into consideration. Improper disposal can be a potential environmental threat.

5.2 EFFECTIVENESS

There was no retrievable evidence regarding the effectiveness of this technology in any of the databases. However, the manufacturer claimed to have a success rate of more than 85% in treating patients and there have been no cases of relapse in which cancer cell re-grew in the same location.[7] The local experts[1] were consulted and they were not in favour of this technology since there were no published evidence on the effectiveness of this technology. In addition, this technology has not been used elsewhere outside China. This devise has no FDA approval (via personal communication with the local experts on the 3rd of July and 6th of July). There are alternatives for conducting radiosurgery. Malaysia has already used the LINAC-based radiosurgery technology which is more established.

5.3 *COST-EFFECTIVENESS*

There is no retrievable evidence on the cost-effectiveness of Gyro-knife. The cost per treatment quoted by the manufacturer is USD 10,000 per treatment in Bangkok and USD 30,000 per treatment in the US. Patient would need one to ten treatment depending on the severity of the patient's condition.[7]

6. CONCLUSION

Currently, there is no retrievable evidence on the safety, effectiveness and cost-effectiveness of Gyro-knife for treatment of cancer.

7. RECOMMENDATION

Radiosurgery is an important treatment alternative to conventional surgery. However the technology that is going to be introduced to this country must have adequate evidence in terms of its safety, effectiveness and cost effectiveness. More clinical outcome research is warranted.

[1] Footnote: The names of the consultants are Mr Johari Siregar bin Adnan, Senior Consultant and the National Advisor for neurosurgery, Mr Azmin Kass Rosman, Consultant Neurosurgeon, Hospital Sungai Buluh and Dr Norshidah bt Abdullah, Consultant Oncologist, Hospital Kuala Lumpur.

8. REFERENCES

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9. APPENDIX

9.1 :Appendix 1 LEVEL OF EVIDENCE SCALE

Level	Strength of evidence	Study design
1	Good	Meta-analysis of RCT, Systematic review
2	Good	Large sample RCT
3	Good to fair	Small sample RCT
4		Non-randomised controlled prospective trial
5	Fair	Non-randomised controlled prospective trial with historical control
6	Fair	Cohort studies
7	Fair	Case-control studies
8	Poor	Non-controlled clinical series, descriptive studies multi-centre
9	Poor	Expert committees, consensus, case reports, anecdotes

SOURCE: ADAPTED FROM CATALONIAN AGENCY FOR HEALTH TECHNOLOGY ASSESSMENT (CAHTA), SPAIN