Neurological and vascular complications of primary and secondary brain tumours: EANO-ESMO Clinical Practice Guidelines for prophylaxis, diagnosis, treatment and follow-up[y]

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Available online 24 November 2020

Key words: brain tumour, brain metastasis, complications, oedema, seizures, thrombosis

INTRODUCTION

The central nervous system (CNS) is affected by a large variety of primary brain tumours and by metastases of cancers originating from other organs. Brain tumours carry a high morbidity and are associated with a range of complications that are rare in cancers affecting other anatomical locations. Neurological symptoms and signs are related to the anatomical area of the CNS involved. There is no symptom or sign specific to primary or secondary brain tumours. Focal or lateralised effects of local tissue destruction include hemiparesis, aphasia and visual field deficits. These lateralised symptoms often present subacutely and show a progressive course over some days or weeks. Leptomeningeal disease typically leads to multifocal signs and symptoms. Most frequently, patients present with headaches, nausea and vomiting, mental changes, gait difficulties, cranial nerve palsies and focal or irradiating (radicular) neck and back pain.[1]

Unspecific symptoms of raised intracranial pressure are headache, with or without nausea and vomiting, cognitive impairment, personality changes and gait disturbances. These symptoms are caused by direct pressure of the growing tumour and oedema, or impairment of cere brospinal fluid (CSF) circulation with consecutive hydro cephalus. The typical holocephalic or unilateral throbbing brain tumour-related headaches are accentuated after supine position, e.g. in the morning, and improve over a period of upright time during the day.[2]

A detailed neurological examination is recommended and a standard evaluation form, e.g. as proposed for the quan titative assessment of brain tumour-related signs and symptoms, with the Neurologic Assessment in Neuro Oncology (NANO) criteria should be used.[3] The form should also be used for the clinical evaluation of patients during follow-up. In addition to overall survival (OS), assessing clinical benefit, especially in patients with brain tumours, constitutes an important endpoint in clinical trials.[4]

The complications associated with brain tumours require specific management strategies for optimal prevention,

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[y] These Guidelines were developed by the European Society for Medical Oncology (ESMO) and the European Association of Neuro-Oncology (EANO). The two societies nominated authors to write the guidelines as well as reviewers to comment on them. These guidelines were approved by the EANO Executive Board and the ESMO Guidelines Committee in July 2020.

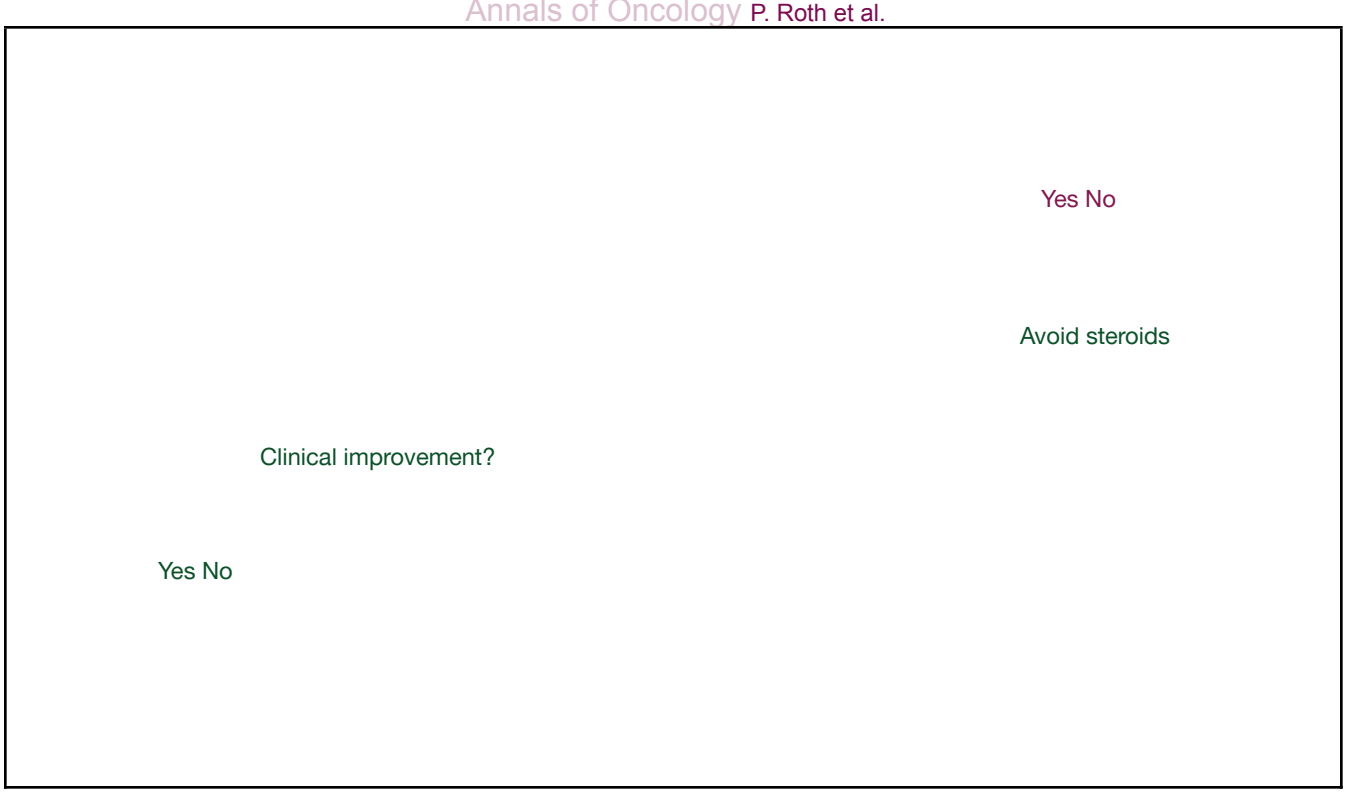

Figure 1. Clinical management of brain oedema in patients with brain tumours.

diagnosis, therapy and follow-up, and necessitate multidis ciplinary cooperation. The current European Association of Neuro-Oncology (EANO)-European Society for Medical Oncology (ESMO) joint guidelines summarise recommen dations for the clinical management of the most important complications observed in brain tumour patients and cover brain oedema, seizures, neurocognitive impairment, venous thromboembolism, stroke, intracranial haemorrhage, met astatic spinal cord compression (MSCC) and supportive and end-of-life care. Due to the lack of high-level evidence on these topics, most recommendations are based on expert opinion and consensus. They aim at guiding clinical man agement of brain tumour patients and end-of-life care and serve as a helpful resource for physicians and health care providers. For the future, prospective clinical trials specif ically enrolling brain tumour patients are needed to better define diagnostic and therapeutic measures of complica tions in this patient group.

BRAIN OEDEMA

Incidence and epidemiology

Primary and secondary brain tumours are frequently sur rounded by oedema. This condition is almost entirely found in malignant neoplasms but occurs also in the context of benign tumours such as meningiomas. As a consequence, the vast majority of brain tumour patients will receive anti oedema treatment at some point during the disease course.[5] Some therapeutic interventions, mainly radio therapy (RT) but also some systemic treatments, may further enhance the oedema surrounding the tumour, leading to increased mass effect and symptom burden.[6] The recognition of tumour-associated oedema and subsequent initiation of adequate therapeutic measures, with consid eration of the overall oncological therapeutic goals, is an important step in the supportive treatment of brain tumour patients aimed at restoring and maintaining the patients' quality of life (QoL) and functional autonomy.

Diagnosis

The diagnosis of tumour-associated oedema is typically made by magnetic resonance imaging (MRI). If the patient is unable to undergo MRI or for other reasons, computed tomography (CT) will also identify oedema. Importantly, the need for anti-oedema treatment is not simply defined by the extent of oedema but should be primarily based on the patient's clinical condition.

Management and monitoring

Anti-oedema treatment should be considered in brain tumour patients requiring relief from neurological deficits (Figure 1). Steroids are the mainstay for

anti-oedema treatment. They act rapidly, can be administered orally or intravenously and are not expensive. Despite their preva lent use, only few data from randomised trials assessing the anti-oedema activity of steroids in brain tumour patients are available. Dexamethasone is the most frequently administered drug.[7] It has potent glucocorticoid activity but hardly any mineralocorticoid effects, which avoids

undesirable alterations of blood electrolyte levels. Furthermore, because of its long biological half-life, a single daily administration is sufficient. Standard doses are in the range of 4-16 mg/day. A randomised trial comparing 4 and 8 mg of dexamethasone as well as 4 and 16 mg per day in patients with metastatic brain tumours did not show a su perior effect of the higher doses on the patients' condition as defined by the Karnofsky performance score (KPS). However, patients receiving higher dexamethasone doses were more likely to suffer from side-effects.[8] There are few alternatives to steroids for this indication. Limited evidence on the anti-oedema activity of boswellic acids, angiotensin II inhibitors, hyperosmolar agents or corticorelin acetate does not support their regular use.[9-12]

Follow-up and long-term implications

Clinically-asymptomatic patients seldom require anti-oedema treatment with steroids. Because of their possible interaction with other agents such as antiepileptic drugs or immuno therapeutics,[13] a critical evaluation of steroid administration is mandatory. The prophylactic use of steroids, e.g. perioper atively or during RTof patients with primary or secondary brain tumours, is increasingly discouraged.[14] The renewed strong interest in steroids and their effect on brain tumour patients results from strong evidence linking steroid use to inferior survival in glioblastoma,[15] and the current interest in immu notherapy approaches for primary and metastatic brain tu mours in which steroid use may be detrimental.[16,17] Patients with clinical symptoms should be treated as long as a clinical benefit can be assumed. Long-term steroid use is associated with significant side-effects such as an increased risk for the development of pneumocystis jiroveci pneumonia (PJP), dia betes, arterial hypertension, osteoporosis, myopathy and psychiatric adverse effects, among others.[18] Therefore, pa tients should be closely monitored with regular clinical examinations to decide whether tapering should be consid ered. No precise rules have been established to define the ideal tapering schedule. Typically, a dose reduction over 2-4 weeks will be appropriate but patients with long-term steroid use may require an even longer period until complete tapering.

Recommendations

Diagnosis of brain oedema should be carried out using T2-weighted or FLAIR MRI sequences [EANO: IV, n/a; ESMO: V, n/a].

Anti-oedema treatment should only be considered in brain tumour patients requiring relief from neurological deficits [EANO: IV; ESMO: V].

Dexamethasone is the drug of choice for the treatment of symptomatic tumour-associated brain oedema [EANO: IV, B; ESMO: V, B].

The initial dexamethasone dose is typically in the range of 4-16 mg/day given as a single daily intravenous (i.v.) or oral administration. The steroid dose should be tapered to the lowest dose needed to control clinical symptoms [EANO: IV, n/a; ESMO: V, n/a].

Appropriate PJP prophylaxis, e.g. with trimethoprim sulfamethoxazole, should be considered in patients requiring steroid treatment of >4 weeks, in those under going RT or chemotherapy (ChT) in parallel, or with a lymphocyte count <1000/ml [EANO: IV, B; ESMO: V, B].

SEIZURES

Incidence and epidemiology

It has traditionally been assumed that the lifetime risk for seizures in adult patients with diffuse gliomas exceeds 50%, notably in patients with World Health Organization (WHO) grade II and III tumours,[19] with a possible link to the presence of isocitrate dehydrogenase (IDH) mutations.[20] A third of patients with meningiomas suffer from seizures before the first surgical intervention and long-lasting tumour control is associated with freedom from seizures.[21] Only 20% of pa tients with newly-diagnosed brain metastases present with seizures, and tumour control is probably the most important predictor of seizure control.[22] For seizures in brain tumour patients, according to the nomenclature proposed by the In ternational League against Epilepsy (ILAE), the most common types will now be referred to as 'focal' seizures and focal to bilateral tonic-clonic seizures.[23] The Response Assessment in Neuro-Oncology Group (RANO) has acknowledged the central role of seizure control for QoL of patients and caregivers and developed guidance on how to implement seizure control as an efficacy endpoint into clinical trials.[24]

Diagnosis

In the absence of a history of a primary or metastatic brain tumour, new onset of epileptic seizures in adults requires neuroimaging, that is, contrast-enhanced cerebral MRI, unless there are contraindications, to

rule out an intracra nial neoplasm. Systemic cancer patients without a history of brain metastases should also be assessed by neuroimaging when developing seizures. Alternative aetiologies include treatment-associated neurotoxicity, infectious diseases, paraneoplastic syndromes, metabolic disturbances and ce rebrovascular disease.[25] New-onset or less well-controlled seizures in patients with primary brain tumours are often indicative of progression; therefore, neuroimaging should be considered even if there is otherwise no change in neurological status. Electroencephalography (EEG) may help in the initial assessment of patients with suspected seizures and can be used to estimate future seizure risk or for the differential diagnosis of altered neurocognitive function or vigilance. An EEG is important to rule out nonconvulsive status epilepticus (NCSE) with worsening neurological symptoms or vigilance problems. EEG will also help to distinguish epileptic seizures from psychogenic seizures.

Management and monitoring

Therapeutic interventions against brain tumours are important contributors of seizure control. This concerns not only surgery, but also RT and ChT.[26] The vast majority of brain tumour patients who experience a seizure should be

placed on anticonvulsant secondary prophylaxis, at least transiently (Figure 2). If surgery is carried out, and if a near gross total resection is achieved, efforts at tapering and stopping anticonvulsant drugs should be undertaken within weeks after surgery, provided there is no recurrent tumour growth. If only a biopsy or partial resection are carried out, with subsequent RT or ChT-induced tumour regression, tapering and stopping can also be considered.

The choice of anticonvulsant agents has become wider with more drugs available over recent years.[27] However, there is lack of robust, randomised, controlled evidence to support the choice of the optimal antiepileptic drug for the treatment of seizures in patients with brain tumours. Of the traditional drugs, valproic acid still has a firm place in some centres, given its efficacy and overall good tolerability. There is no evidence of a higher rate of perisurgical bleeding complications with valproic acid prophylaxis. Val proic acid must not be used in females who may become pregnant and interactions with other drugs need to be checked on a regular basis. Phenytoin, phenobarbital and carbamazepine are no longer recommended as agents of first choice because of their side-effect profile and drug interactions, especially with steroids and various cytotoxic and targeted agents. Levetiracetam has become the drug of first choice at most neuro-oncology centres in recent years, although psychiatric side-effects in some patients remain a concern.[28] Lamotrigine has good antiseizure activity but requires a period of several weeks until sufficient drug levels are reached. Lacosamide may assume a larger role as an add-on treatment for patients whose seizure disorder is not controlled by monotherapy.[29] Patients and caregivers should be instructed how to behave and whom to contact in case of recurrent seizures.

Follow-up

Brain tumour patients with a history of seizures are ques tioned on the occurrences of potential seizures at each follow-up visit. Serum levels of anticonvulsant drugs can be determined to explore failure to control the epileptic ac tivity, to assess compliance and for the differential diagnosis of potential drug-related side-effects.

Recommendations

New-onset seizures in cancer patients without a history of brain tumour should trigger neurological work-up, including cerebral MRI [EANO: IV, B; ESMO: V, n/a].

Since worsening of a pre-existing seizure disorder in brain tumour patients often heralds tumour progression, repeat MRI and other potentially necessary work-up such as blood and CSF examination should be considered [EANO: IV, B; ESMO: V, n/a].

Primary anticonvulsant prophylaxis is not indicated in brain tumour patients [EANO: I, D; ESMO: I, D].

Levetiracetam and lamotrigine are preferred options of first choice because of their efficacy and overall good tolerability [EANO: IV, n/a; ESMO: V, n/a].

Brain tumour patients who have suffered epileptic sei zures and are not candidates for surgery should receive secondary prophylaxis until local control has been achieved [EANO: IV, n/a; ESMO: V, n/a].

Enzyme-inducing anticonvulsants should be avoided in patients with brain tumours [EANO: III, D; ESMO: III, D]. Judgements on the competency to drive need to adhere to national guidelines and law and should consider not only epilepsy but also other aspects of neurological and neurocognitive function [EANO: IV n/a; ESMO: V, n/a].

NEUROCOGNITIVE IMPAIRMENT

Incidence and epidemiology

Cognitive impairment, including deficits in domains such as memory, attention and executive functioning, has a large impact on the QoL of brain tumour patients.[30,31] It is caused by the tumour itself, as well as by antitumour treatment, supportive treatment and

patient characteristics such as age and response to psychological stress. Cognitive impairment is already present in 90% of patients with a primary brain tumour[32] and in 91% of patients with brain metastases[33] before treatment. Even patients with benign meningiomas show subtle cognitive deficits.[34]

Diagnosis and pathology

Various factors including tumour location, size and histology are associated with the extent and severity of cognitive impairment. Apart from local damage, brain tumours also cause global cognitive dysfunctioning by disruption of cognitive networks. Memory and executive functioning are the most frequently impaired domains.[35] Antitumour treatment with surgery, RT or ChT may affect cognitive functioning, both in a positive as well as in a negative way. Resection of the tumour may result in cognitive improve ment by relieving elevated intracranial pressure. Conversely, damaging the surrounding tissue may cause transient or permanent cognitive deficits.[36] RT-induced cognitive impairment can be subclassified by its temporal evolution. Short-term cognitive deficits, presenting during and shortly after RT, may result from elevated intracranial pressure and fatigue. Delayed side-effects, which may develop months to years after RT, range from local radionecrosis to diffuse leukoencephalopathy and cerebral atrophy, and may be associated with irreversible cognitive decline that can ulti mately lead to dementia.[37,38] Demyelination and small vessel damage are likely the cause of this syndrome. Neural stem cells residing in the hippocampus and subventricular zone are suspected to be a critical target of RT-associated cognitive decline.[39] Systemic ChT may also cause acute and short-term cognitive side-effects[40]; moreover, long term ChT-related changes in cognitive functioning have been summarised under the concept of the chemobrain.[41]

Cognitive impairment is measured with validated neu ropsychological tests that evaluate different domains of cognitive functioning, including attention, processing speed,

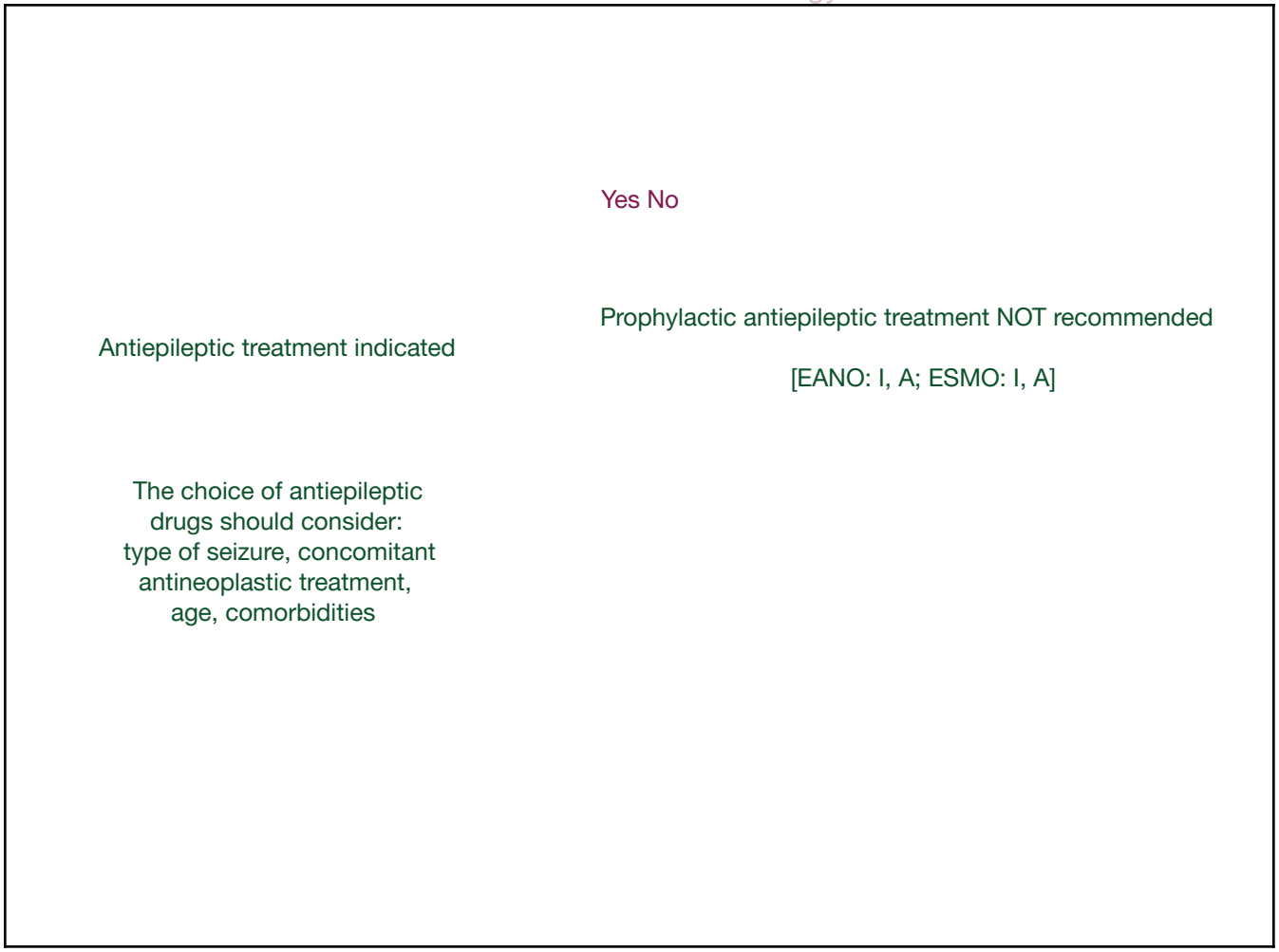

Figure 2. Clinical management of seizures in patients with brain tumours.
ChT, chemotherapy.

memory, visuospatial functioning and executive functioning. Among validated neuropsychological tests are the Hopkins verbal learning test for verbal memory, the ReyeOsterrieth complex figure test (visuoconstruction, visual memory), the controlled oral word association test (verbal fluency), the Stroop test (interference, executive functioning) and the trail making test (attention, executive functioning). Self perceived cognitive functioning, which is only moderately correlated with objective cognitive functioning,[42] reflects cognitive complaints experienced by patients and is assessed with validated questionnaires, such as the cogni tive failures questionnaire and the medical outcomes study subjective cognitive functioning scale.

Treatment

Preventing cognitive side-effects due to antitumour treat ment may primarily be achieved by administering treatment strategies that have a less detrimental effect on cognition. Intraoperative techniques such as awake craniotomy or mapping of eloquent brain functions may preserve cognitive and neurological integrity.[43] Limited dose per fraction and lower overall radiation dose, focal RT instead of whole brain radiotherapy (WBRT) and hippocampal sparing during WBRT[44] may reduce the risk of cognitive deficits.[38,45,46] Proton RT in selected brain tumour patients may contribute to preservation of cognitive functioning by sparing normal tissue to a larger extent than traditional photon treatment.[47] However, at this point, for most brain tumour types such as diffuse gliomas, there are no solid data from randomised trials on the use of proton RT available. Therefore, it remains to be seen if future studies will demonstrate that proton therapy is superior to con ventional RT in terms of efficacy or toxicity.[48]

Cognitive side-effects that may occur due to antiepileptic therapy[49] can partly be overcome by dose adjustments, withdrawal when safely possible or replacement by alter native antiepileptic drugs. Pharmacological intervention studies have investigated the use of methylphenidate,[50] donepezil,[51,52] memantine[53] and a combination of methyl phenidate and modafinil[54] to improve cognitive functioning. Although some studies have reported a beneficial effect, limitations in methods and study design, such as the lack of a control group, impede generalisation of the results.

Rehabilitation programmes, including cognitive rehabili tation and exercise training, may reduce cognitive defi cits.[55-58] A large randomised study that aimed at improving cognitive functioning by offering a cognitive rehabilitation programme showed a subjective improvement in patients with WHO grade II and grade III gliomas as well as an improved attention and verbal memory 6 months after treatment, compared with the waiting-list control group.[58]

Follow-up

Monitoring patients' cognitive functioning during the course of the disease provides information on the impact of a specific treatment strategy. As cognitive deficits may present later in the disease, regular monitoring and long term follow-up are essential for both clinical trials and in clinical practice.

Recommendations

Antitumour treatment strategies that prevent or mini malise cognitive impairment should be prioritised [EANO: IV, n/a; ESMO: V, n/a].

Rehabilitation should be considered, especially in young patients with a favourable prognosis, and in stable brain tumour patients with cognitive complaints and deficits [EANO: IV, n/a; ESMO: V, n/a].

Regular monitoring and long-term follow-up of patients' cognitive functioning is essential, both in clinical trials and in clinical practice [EANO: IV, n/a; ESMO: V, n/a].

VENOUS THROMBOEMBOLISM AND STROKE Incidence and epidemiology

The risk of venous thromboembolism (VTE) is increased in cancer patients, with a particularly high risk in brain tumour patients.[59,60] An incidence of 22%-30% of symptomatic VTE has been reported in contemporary cohorts of glioblastoma patients.[61,62] The probability of VTE is high already at diag nosis and during the initial phase of chemoradiotherapy. Recurrent VTE may be observed in a third (27%) of glio blastoma patients.[61] In an analysis of three randomised tri als, patients with newly-diagnosed glioblastoma, treated with therapeutic anticoagulation between the start of concomitant temozolomide with RT and the start of main tenance temozolomide, had profoundly decreased survival. No decrease in survival was observed in patients treated with prophylactic doses of anticoagulants or with anti platelet agents. It remains unclear whether venous throm boembolic events caused this survival difference.[63] VTE has been less investigated in patients with brain metastases; however, a retrospective study reported an incidence of 20%.[64] The incidence is probably underestimated,

and an increasing number of asymptomatic VTEs, incidentally found on CT scans done for tumour staging or other reasons such as imaging for exclusion of suspected VTE or pulmonary embolism (PE), have been reported.[65]

Potential risk factors among glioma patients include age, leg paresis, higher WHO grade of the tumour, high levels of circulating P-selectin or high expression of podoplanin in the tumour, intraluminal thrombosis as well as high leukocyte

and low platelet counts.[66-68] In contrast, IDH mutant gliomas may have a lower VTE risk. Treatment-related factors such as cancer surgery, including neurosurgical interventions, irradi ation, ChT and steroid administration, the presence of indwelling catheters and supportive treatments such as frequent transfusions add to VTE risk.[69] While bevacizumab may increase the risk of VTE in the general population of cancer patients by 33%,[70] no increased risk has been observed in the phase III trials exploring bevacizumab in newly-diagnosed or recurrent glioblastoma.[71-73]

Diagnosis

The diagnosis of VTE can be challenging because symptoms and signs may be unspecific and brain tumour patients often have neurological deficits, which can be clinically more dominant and mask VTE-related symptoms and signs. Classic symptoms include leg swelling, erythema and pain of the limb for deep vein thrombosis (DVT), and tachycardia, thoracic pain, shortness of breath or haemoptysis for PE. Of note, in most patients with a diagnosis of unsuspected or incidental PE, fatigue was the leading symptom.[74,75] The diagnostic approach to cancer patients with suspected PE or DVT has not been specifically investigated. Therefore, general diagnostic work-up including assessment of the clinical pre-probability of VTE, D-dimer testing[76] and imaging have to be applied in clinical practice to rule out DVT and/or PE. Compression ul trasound is the method of choice to diagnose DVT and CT pulmonary angiogram for PE (Figure 3). However, there is a need for further research to establish validated algorithms for the diagnostic work-up of a suspected DVT and/or PE in pa tients with cancer, including brain tumours.

Primary thromboprophylaxis

Pharmacological thromboprophylaxis is the mainstay in the prevention of VTE. Non-pharmacological methods for the perioperative prophylaxis of VTE include early mobilisation, compression stockings and external pneumatic compression devices. Mechanical and pharmacological approaches may be combined to reduce the risk of VTE.[77,78] In general, pa tients with cancer, with and without metastatic disease, who are hospitalised with acute illness or confined to bed due to immobility are recommended to receive prophylactic thromboprophylaxis for the duration of the hospital stay.[79,80] The administration of low-molecular weight hep arin (LMWH) or unfractionated heparin reduces the risk of postoperative VTE in patients undergoing a surgical pro cedure by 50%, without increasing the risk for major intracranial haemorrhage.[79-82] Pharmacological thrombo prophylaxis in brain tumour patients should be initiated within 24 hours after surgery.[83] Patients affected by other cancers undergoing major surgery should receive prophy lactic treatment, preferably with LMWH for 7-10 days after standard surgery, but up to 1 month in cases of major abdominal or pelvic surgery.[79,80] For brain tumour patients undergoing a neurosurgical intervention, the optimal duration of prophylaxis has not been defined. Whether the recommendations regarding prolonged use of primary

D-dimer testing, compression ultrasound
(DVT) and/or CT pulmonary angiogram (PE)

Diagnosis confi rmed Diagnosis NOT confi rmed

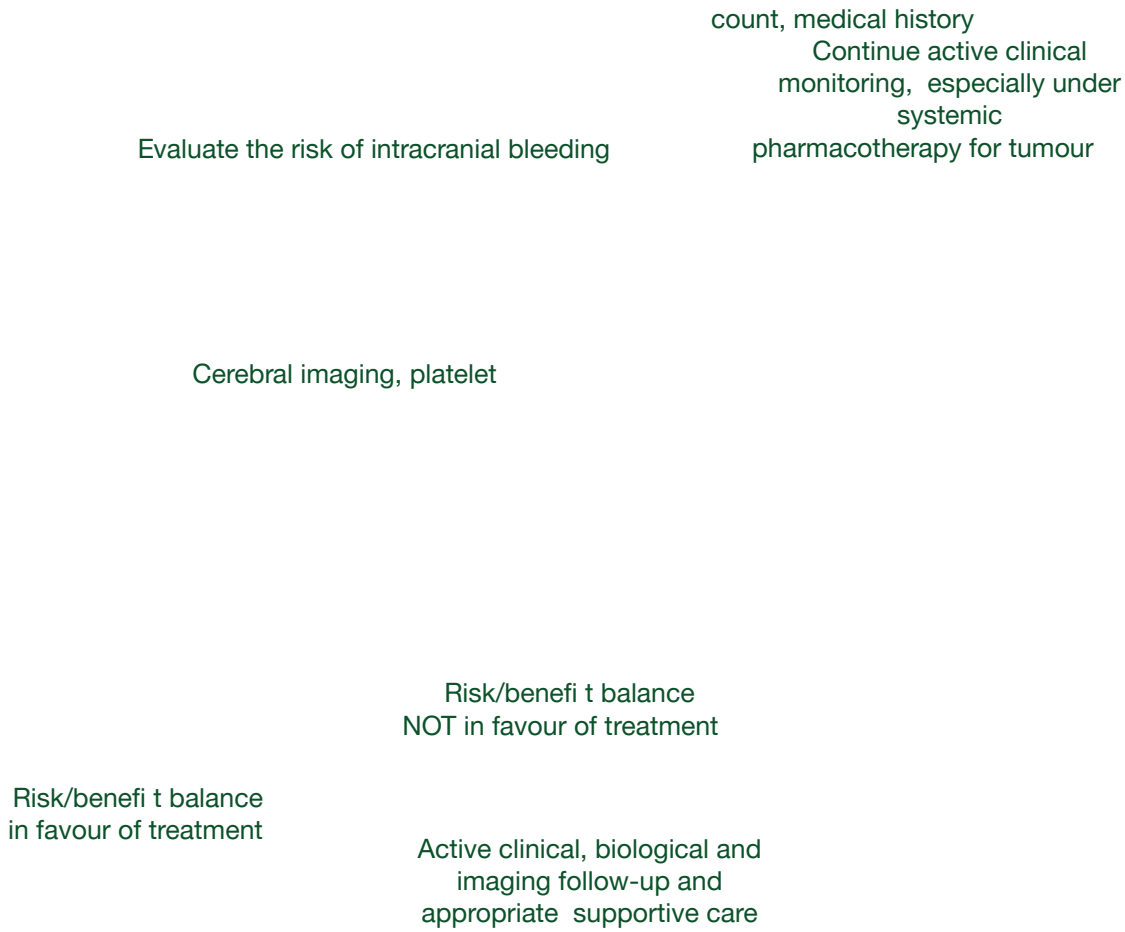

Figure 3. Clinical management of venous thromboembolism in patients with brain tumours.
CT, computer tomography; DVT, deep vein thrombosis; LMWH, low-molecular weight heparin; PE, pulmonary embolism; VTE, venous

thromboprophylaxis beyond hospital discharge for up to 1 month can be extrapolated to patients with brain tumours upon surgery remains therefore elusive. Only one rando mised trial explored the role of LMWH for primary pre vention of VTE in patients with newly-diagnosed grade III or grade IV glioma, but no firm conclusion could be drawn as the trial was stopped prematurely.[84]

Two randomised placebo-controlled trials, AVERT and CASSINI, evaluated the efficacy and safety of primary pro phylaxis with a direct oral anticoagulant (DOAC) for 6 months in ambulatory patients at intermediate to high risk of VTE.[85,86] Pooled analyses demonstrate a relative risk reduction of VTE by 45% and low risk of major bleeding.[87] Patients with primary brain tumours or brain metastasis only were eligible in the AVERT study, comparing apixaban 2.5 mg twice daily with placebo. OS did not differ between groups receiving primary thromboprophylaxis with DOAC versus placebo. More data are needed to draw firm con clusions and to demonstrate the clinical benefit and safety of primary thromboprophylaxis with a DOAC in patients with primary and secondary brain

tumours.

Treatment of VTE

Once the diagnosis of VTE has been confirmed, anti coagulation should start immediately. Parenteral anticoag ulants (e.g. LMWH) are recommended for treatment and secondary prevention of VTE in patients with active cancer for 3-6 months, including those with brain tumours.[88-93] LWMHs are more effective in reducing the risk of VTE recurrence than vitamin K antagonists without increasing the risk of major bleeding.[89]

The incidence of intracranial haemorrhage in patients treated with therapeutic anticoagulation may be increased for glioma patients.[94] In glioblastoma patients, an incidence of intracranial haemorrhage of 3%-5% has been reported under prophylactic LMWH.[84,95,96] In contrast, the risk of intracranial haemorrhage for patients with brain metastases treated with therapeutic anticoagulation is probably not increased.[64,94,97] The institution of anticoagulation in pa tients with asymptomatic bleeding on MRI requires a careful risk/benefit assessment. Other risk factors for intracranial haemorrhage should be considered; in partic ular, anticoagulation should be managed and adjusted to the platelet count.[98] More detailed information on the management of intracranial haemorrhage is available in the Supplementary Material, available at https://doi.org/10.1016/j.annonc.2020.11.003.

The evidence for duration of treatment >6 months is scarce.[99,100] After 6 months of treatment, anticoagulation can be stopped in patients who are in complete remission and should be continued in patients with active cancer or those receiving ongoing anticancer treatment.

The efficacy and safety of DOAC versus LMWH for treatment and secondary prevention of VTE in patients with cancer have been investigated in two randomised controlled trials (RCTs), the HOKUSAI VTE cancer (edoxaban versus dalteparin) and the SELECT-D study (rivaroxaban versus dalteparin).[101,102] Edoxaban and rivaroxaban were equally or slightly more effective for the prevention of VTE recurrence but conferred a higher risk of major bleeding than dalteparin, particularly in patients with gastrointestinal cancer. Brain tumour patients were underrepresented or not included in these two trials; thus, more research is needed to provide insight into the efficacy and safety of DOAC in patients with brain tumours. In the absence of specific data for the cancer patient population, intracranial venous sinus occlusion should be treated with LMWH, although high quality evidence is missing.[103]

Ischaemic stroke

The risk of stroke in cancer patients is higher than in the general population.[104-106] In glioma patients, strokes are not associated with the WHO grade and do not differ between histological subtypes.[107] In primary brain tumour patients, the main causes of ischaemic stroke include postoperative ischaemic stroke and stroke as a possible late consequence of RT and hypercoagulable states.[107,108] Bevacizumab may moderately increase the risk of stroke.[71-73,107] No specific data are available on brain metastasis patients. In glioma patients, 15%-25% of strokes are asymptomatic and are diagnosed on MRI only.[109,110] The interpretation of brain MRI can be challenging when changes in diffusion-weighted imaging are close to the tumour area where post therapeutic changes remain a differential diagnosis.[107,108]

The management depends on the underlying cause, the neurological condition of the patient and the prognosis associated with the brain tumour. Patients with malignant intracranial tumours were commonly excluded from trials evaluating i.v. or local thrombolysis. The use of thrombolytic agents such as recombinant tissue plasminogen activator in patients with malignant brain tumours can therefore not be generally recommended. Antiplatelet drugs should be considered for secondary prophylaxis as in the general ischaemic stroke patient population.

Other vascular complications

Other vascular complications include thrombotic micro angiopathy, posterior reversible leukoencephalopathy syn drome, radiation-induced vasculopathy including stroke-like migraine attacks after RT (SMART) syndrome, moyamoya like vasculopathy and microbleeds.

Recommendations

Routine primary thromboprophylaxis in the ambulatory setting is not recommended for all brain tumour patients [EANO: IV, n/a; ESMO: V, C].

Primary thromboprophylaxis should be considered for hospitalised brain cancer patients with acute medical illness or immobilisation [EANO: IV, C; ESMO: V, C].

LMWH should be considered as the first line of primary thromboprophylaxis of VTE for patients with brain tumours after brain tumour surgery [EANO: II, B; ESMO: II, C].

Primary thromboprophylaxis should be initiated within 24 hours after brain surgery for brain tumour patients [EANO: III, C; ESMO: V, C].

Therapeutic doses of LMWH should be used for

treat ment of VTE in brain tumour patients [EANO: IV, C; ESMO: V, C].

DOAC (edoxaban and rivaroxaban) should not be routinely considered as an alternative for brain tumour patients with VTE [EANO: IV, C; ESMO: V, C].

The duration of therapeutic anticoagulation for treatment of VTE should be 6 months for brain tumour patients who are in complete remission and should be prolonged in pa tients with active cancer or those receiving ongoing anti cancer treatment [EANO: IV, C; ESMO: V, C].

Antiplatelet drugs should be considered for secondary prophylaxis of stroke in patients with brain tumours un less there is an underlying cause such as atrial fibrillation that requires therapeutic anticoagulation according to standard stroke guidelines. [EANO: IV, n/a; ESMO: V, C].

The management of metastatic spinal cord compression as well as recommendations regarding supportive therapy and end-of life care in brain tumour patients are described in the Supplementary Material, available at https://doi.org/10.1016/j.annonc.2020.11.003.

METHODOLOGY

These clinical practice guidelines were developed in accor dance with the ESMO standard operating procedures for Clinical Practice Guidelines development (http://www.esmo.org/Guidelines/ESMO-Guidelines-Methodology). The relevant literature has been selected by the expert authors. Levels of evidence and grades of recommendation have been applied using the system shown in Supplementary Tables S3, S4 and S5, available at https://doi.org/10.1016/j.annonc.2020.11.003.[111,112] Statements without grading were considered justified standard clinical practice by the experts and the EANO Faculty and ESMO Faculty. This manuscript has been subjected to an anonymous peer re view process.

ACKNOWLEDGEMENTS

The authors thank Dr Franziska Schlieter for editorial assistance. The ESMO Guidelines Committee thank the EANO Faculty, the ESMO Faculty and other experts who provided critical reviews of these ESMO Clinical Practice Guidelines. They also thank the European Cancer Patient Coalition and the following patient organisation for their review: The Glioma Center.

FUNDING

No external funding has been received for the preparation of these guidelines. Production costs have been covered by ESMO from central funds.

DISCLOSURE

PR has received honoraria for lectures or advisory board participation from Bristol-Myers Squibb, Covagen, Debio pharm, Merck Sharp and Dohme, Novocure, QED and Virometix and research support from Merck Sharp and Dohme; AP has received honoraria for advisory board participation from AbbVie; ELR has received research grants from Mundipharma and Amgen and honoraria for lectures or advisory board participation from AbbVie, Daiichi Sankyo, Mundipharma and Novartis; MW has received research grants from AbbVie, Adastra Pharmaceuticals, Bayer, Merck, Sharp and Dohme, Merck (EMD), Novocure, OGD2 Pharma, PIQUR Therapeutics and Roche and honoraria for lectures or advisory board participation or consulting from AbbVie, Bristol-Myers Squibb, Celgene, Merck, Sharp and Dohme, Merck (EMD), Novocure, Orbus, Pfizer, Progenics, Roche and Tocagen; CA has received honoraria for lectures, consul tancy or advisory board participation from Bayer, Bristol Myers Squibb, Boehringer Ingelheim, Daiichi Sankyo, Pfizer and Sanofi; EC-JM has reported advisory board and/or has received honoraria from Merck Serono, Accuray and Brainlab and research grants from Merck Serono and AstraZeneca; RG has received honoraria for lectures, con sultancy or advisory board participation from Kiowa Kirin, Angelini Pharma, Bristol-Myers Squibb, Boehringer Ingel heim, Merck, Sharp and Dohme, Roche and AstraZeneca; KJ has reported advisory board and/or honoraria for pre sentations for Merck, Sharp and Dohme, Helsinn, Tesaro, Amgen, Hexal, Pfizer, Voluntis and Kreussler Pharma; RN has received research support from Merck, Sharp and Dohme, Chugai and Eisai and honoraria for lectures, consultancy or advisory board participation from Chugai, Eisai, ONO, AbbVie, Daiichi Sankyo and Novocure; RR has received honoraria for lectures or advisory board participation from UCB and Novocure; MP has received research support from Böehringer Ingelheim, GlaxoSmithKline, Merck, Sharp and Dohme and Roche and honoraria for lectures, consultancy or advisory board participation from Bristol-Myers Squibb, Novartis, Gerson Lehrman Group, CMC Contrast, Glaxo SmithKline, Mundipharma, Roche, AstraZeneca, AbbVie, Lilly, MEDahead, Daiichi Sankyo and Merck, Sharp and Dohme; MC, FW, SV, MJBT, YKH and WW have declared no conflicts of interest.

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