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Review

Management of neurotoxic reactions induced by antibody-drug conjugates

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ABSTRACT

In recent years, many new antitumor drugs have been approved for clinical use. Among them, antibody-drug conjugates (ADCs) are an innovative drug group that combines the advantages of chemotherapy with a cytotoxic drug and targeted therapy with monoclonal antibodies. However, although ADCs provide survival benefits to patients, their special composition and mode of action also lead to specific adverse effects. Among the common adverse effects caused by ADCs, peripheral neuropathy (PN) affects patients' quality of life and also present significant challenges to clinical nursing. There are several guidelines and consensus for treating chemotherapy-induced peripheral neuropathy. However, there are no specific guidelines for managing PN caused by ADCs. Nurses play an important role in the prevention and management of PN, and their relevant knowledge and skills for symptom assessment, functional deficit screening, patient referral and advocacy, and patient education are indispensable. By combining Chinese and international guidelines, consensus, and related studies, this paper reviewed the occurrence and characteristics of ADC-induced PN and highlighted the principles of prevention, treatment, and nursing care to provide a reference for clinical nursing practice and improve the safety of ADCs for patients.

Introduction

With advances in medical technology, an increasing number of anticancer drugs have been introduced for clinical application. These drugs include antibody-drug conjugates (ADCs) that combine the selectivity of monoclonal antibodies with the targeted cell killing properties of the payload to release cytotoxic agents into the tumor mass, thereby achieving tumor cell killing effect through "targeted chemotherapy."[1] ADCs are currently a highly targeted anticancer biological product. They are different from the drugs used in previous chemotherapy regimens or targeted therapies. ADCs are based on an innovative approach that combines the advantages of chemotherapy and targeted therapy; this combination overcomes the limitations of the single therapy approach and explores the development of improved anticancer drugs based on the three core components of ADCs: a tumor-homing carrier, payload, and a linker. This strategy has been successfully used to enhance the therapeutic effects of cytotoxic drugs and reduce their toxic side effects. Moreover, this approach has high potential to change the effectiveness of current cancer treatments and is presently being intensively studied worldwide.[2] At present, 15 ADC-based drugs have been approved globally for use in hematological and solid tumors.[3]

Although ADCs provide survival benefits to patients, their unique composition and mode of action also lead to specific adverse effects. Based on the affected organs and tissues, the common adverse effects are classified as hematological-related adverse effects, infusion-related effects, neurotoxicity, hepatotoxicity, pulmonary toxicity, digestive system toxicity, cardiotoxicity, and infection.[1,4] Different degrees of adverse effects show varying influence on patients' quality of life, and the anticancer treatment might be delayed or interrupted by severe adverse effects. Among the common adverse effects, peripheral neuropathy (PN) caused by ADCs affects patients' quality of life and presents challenges to clinical nursing. This review focuses on the occurrence of neurotoxic reactions induced by ADCs and the key points of nursing care for patients with ADC-related adverse effects.

Overview

Mechanism of ADC-induced neurotoxicity

The three core components of ADCs have specific roles: the tumor-homing carrier targets the specific tumor antigen, the payload exerts cytotoxic effects, and the linker maintains a stable connection between the

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carrier and the payload. Each component influences the pharmacological and clinical properties of ADCs as well as their adverse effects. The adverse effects are related to target (antigen) selection, mechanism of drug action, linker chemical property, and coupling site. Therefore, the safety evaluation of ADCs should involve not only referring to the known information of a single component but also measuring the possible pharmacokinetics and tissue distribution changes of each component comprehensively in the adverse effects caused by the specific combination of ADCs.[5]

The main factor of ADC-induced PN is the payload with cytotoxic effects. The mechanism of PN is similar to that of chemotherapy-induced peripheral neuropathy (CIPN). ADC-induced PN is the common adverse effect caused by the payload containing monomethyl auristatin E (MMAE). The underlying reason for this effect is the nonspecific uptake of the ADC in peripheral nerves and release of MMAE, leading to the inhibition of microtubule-dependent axon transport and neurodegeneration. Furthermore, DM1-induced axonal degeneration might be the underlying mechanism for ado-trastuzumab emtansine (T-DM1)-associated PN.[6]

Incidence of ADC-induced PN

The incidence, severity, and clinical pattern of PN during treatment with ADCs vary widely. A signal detection study that using Reporting Odds Ration (ROR) and Information Component (IC) method of the PN events associated with eight ADC-based drugs showed that brentuximab vedotin (BV), T-DM1, polatuzumab vedotin (PV), and enfortumab vedotin (EV) were correlated with PN events, which could occur on the first day of medication, resulting in severe consequences.[7] The number of PN events occurring on the first day of medication with BV, PV, or EV constituted ≥ 20% of the total cases. The median time for PN events was 1–3 dosing courses (21–63 d) for BV, T-DM1, and PV. BV, T-DM1, PV, EV, tisotumab vedotin-TFTV (TV), mirvetuximab (Elahere), and disitamab vedotin (DV) can pose a risk for developing PN. Furthermore, although the severity of PN incidence varied (13% to 62%), most of them were Grade 1–2.[4] Table 1 shows the current reported incidence of ADC-induced PN.

Clinical manifestations of PN

The clinical manifestations and severity of PN are associated with a wide range of pathological changes, such as lesions related to peripheral nerve cells and fibers. Motor, sensory, and autonomic nerve fibers are implicated in PN occurrence. The symptoms are mainly manifested as sensory nerve damage, such as hypoesthesia, hyperesthesia, paresthesia and burning pain, formication of hands or feet, glove-and-stocking feeling due to paresthesia of the extremity, and other symptoms of

Table 1
Incidence of ADC-induced PN.

Name	Indication	Treatment protocols	Incidence rate			Mitigation			Median time from onset to resolution or improvement	Ongoing neuropathy rate (%)
			Any grade (%)	≥ Grade 3 (%)	Median time to onset	Complete resolution (%)	Partial improvement (%)	Non-remission (%)		
BV	HL[8,9]	BV on day 1 of a 21-day cycle, lasting up to 16 cycles	56	10	13.7 w (0.1–47.4)	62	24	14	23.4 w (0.1–138)	38
	HL[9,10]	BV + Adriamycin + Vincristine + Dacarbazine on days 1 and 15 of a 28-day cycle, up to 6 cycles at most	67	10	2 m (0–7)	71	13	16	resolution: 34 w (13–71); improvement: 49 w (30–129)	19
	HL[9,11]	BV + cyclophosphamide + doxorubicin + prednisone for a 21-day cycle, up to 6–8 cycles	52	<4	2 m (<1–5)	50	12	38	4 m (0–45)	21
PV	DLBCL[12,13]	PV + Rituximab + Cyclophosphamide + Doxorubicin + Prednisone for a 21-day cycle, up to 8 cycles	52.9	1.6	2.3 m	58	-	-	4 m	-
	Relapsed/ refractory DLBCL[13,14]	PV + Bendamustine + Rituximab or Obinutuzumab for a 21-day cycle, up to 6 cycles	40	2.3	2.1 m	48	17	35	1 m	-
DV	Advanced solid tumor[15]	DV on a continuous dose increase	43.9	14.0	-	-	-	-	-	-
	Gastric or gastroesophageal junction cancer[16]	DV 2.5 mg/kg every 2 weeks	32.8	3.2	-	-	-	-	-	-
TV[17]	Cervical cancer	TV 2 mg/kg every 3 weeks	42	8	2.4 m (0–11.3)	17	17	66	-	-
EV[18]	Urothelial cancer	EV 1.25 mg/kg on days 1, 8, and 15 of a 28-day cycle	53	5	≥ Grade 2; 4.9 m (0.1–20)	14	46	40	-	86
	Urothelial cancer	EV 1.25 mg/kg on days 1 and 8 of a 21-day cycle; palizizumab 200 mg on day 1	65	3.3	≥ Grade 2; 6 m (0.3–25)	-	-	-	-	-
Elahere	Ovarian cancer[19,20]	Elahere 6 mg/kg every 3 weeks	36	2	1.3 m (0.03–29.1)	28	13	59	-	-
T-DM1	Breast cancer[21]	T-DM1 3.6 mg/kg every 21 days	21	2.2	-	-	-	-	-	-
	Breast cancer[22]	T-DM1 3.6 mg/kg every 21 days, up to 14 cycles	18.6	1.4	-	74.6	-	-	-	-

BV, brentuximab vedotin; HL, Hodgkin lymphoma; PV, polatuzumab vedotin; DLBCL, Diffuse large B-cell lymphoma; DV, disitamab vedotin; m, month; TV, tisotumab vedotin-TFTV; EV, enfortumab vedotin; T-DM1, ado-trastuzumab emtansine; w, week.

neuralgia. Severe cases of PN can cause limb weakness, difficulty in performing a squat, inability to walk, and tendency to stay in bed, which seriously affects the patient's activities of daily living.[4] Different ADCs lead to various clinical manifestations of PN.

Prevention and treatment of PN

At present, there are no specific clinical guidelines or consensus regarding the management of PN caused by ADCs. Because the mechanism of ADC-induced PN is similar to that of CIPN, the prevention, management, and nursing strategies of CIPN can also be used for patients receiving ADCs.[4,23] Several guidelines and consensus on the diagnosis and management of CIPN have been published by Chinese Anti-Cancer Association,[24] American Society of Clinical Oncology,[25] and European Society for Medical Oncology,[26] which currently serve as a reference for clinical staff.

Prevention

Several guidelines and consensus indicate the absence of high-quality evidence regarding the prevention of PN by effective drugs,[24–26] moreover, acupuncture-based prevention is not recommended presently.[24] Some measures are suggested to prevent and reduce the occurrence of PN, with varying levels of evidence and recommendations, including the use of anticonvulsants, antidepressants, vitamins, minerals, and other chemical protective agents (evidence level: II, recommendation level: weak),[24] such as topical low-concentration menthol cream (evidence level: III, recommendation level: B).[26] Adjusting the dose and time interval of drugs can help reduce the occurrence of severe PN (evidence Level: II, recommendation level: weak).[24] Cryotherapy with, for example, frozen socks and gloves can prevent and reduce the incidence of PN induced by certain chemotherapeutic drugs (such as taxanes) (evidence level: II, recommendation level: strong).[24] Compression therapy using surgical gloves is also suggested (evidence level: III, recommendation level: weak).[24,26]

Treatment

Dose adjustment. The main treatment strategy for PN is reduction of drug dose and/or prolongation of the medication interval cycle.[23,25] An expert consensus on the clinical application of ADCs for treating malignant tumors suggests the adjustment of the drug dose according to the degree of PN induced by ADCs.[4] Grade 1 or 2 PN generally does not require dose adjustment. Grade 3 or 4 PN is mainly managed by dose reduction and/or prolongation of the medication interval cycle. Treatment with ADCs should be stopped when relatively severe PN (Grade 3) occurs during the treatment course, such as unsteady walking due to limb weakness and the need for auxiliary tools to walk, or limb numbness and pain, which still adversely affects the patient's quality of life and leads to difficulties in life after drug treatment for neuralgia. If the symptoms improve and the patients are able to take care of themselves, the treatment could be restarted with the ADC dose adjusted to a lower level. If more severe PN (Grade 4) occurs that threatens the patient's life, ADC therapy should be discontinued immediately.[4]

Pharmacological treatment. Paresthesia and neuropathic pain are the main symptoms of PN. When patients experience chronic PN, treatment approaches focus on the reduction or relief of neuropathic pain (evidence level: IV, recommendation level: A).[26] Nutraceutical drugs are usually used to improve the clinical symptoms of paresthesia in PN patients.[23] Medications that may be used for PN-associated paresthesia include B vitamins (B1, B6, B12, and B complex vitamins), folic acid, and niacinamide. Recommended medications for neuropathic pain include tricyclic antidepressants (amitriptyline), selective serotonin reuptake inhibitor, norepinephrine reuptake inhibitors (duloxetine and venlafaxine), calcium antagonists (gabapentin and pregabalin), and opioids.[26] Duloxetine is the only agent with appropriate evidence to support its use as the first-line drug for patients with confirmed neuropathic pain (evidence level: intermediate, recommendation level: moderate).[25] The other recommended drugs were reported by studies on patients with other types of neuropathic pain or with lower evidence level.[25,26] Systemic drug therapy should proceed through slow titration from a low starting dose until the optimal efficacy is achieved and adverse effects are controlled, while paying attention to the effects of drug combinations.[24]

Non-pharmacological treatment. This treatment approach includes physical exercise, acupuncture, auricular plaster therapy, cryotherapy, and compression therapy. As a supplementary method, acupuncture is safe and effective with a low incidence of adverse effects.[24,26] Exercise, functional training (e.g., vibration training), and interventions involving physical or occupational therapy can improve strength and balance in patients with PN and ameliorate several other functional deficits.[26,27] Physical exercise can be started earlier at the same time when potentially neurotoxic cancer treatment is initiated, which can reduce the incidence of PN to a certain extent.[26,28] The incidence of PN can be substantially reduced by traditional Chinese medicine washout and auricular plaster therapy.[24,26] Cryotherapy and compression therapy can improve and alleviate symptoms and reduce the functional impairment.[24,29]

Nursing care

Nurses play a key role in assessing patient symptoms, screening functional deficits, referring patients to appropriate healthcare services and counseling them, and educating patient about their health status.

Assessment of risk factors for ADC-induced neurotoxicity and identification of high-risk groups

Several factors influence susceptibility to PN. These include (1) therapy-related risk factors,[23,24,30] such as the type of ADCs, dosage, exposure time, and use/no use of combination therapy, (2) individual-related risk factors, such as advanced age, obesity, smoking, alcoholism, diabetes, anxiety, and depression,[26] and (3) disease-related factors, such as presence of anemic or proinflammatory conditions, with increased levels of the proinflammatory factors interferon-γ and interleukin-1β as well as a decreased level of the anti-inflammatory factor IL-10.[24] Concurrent exposure to other neurotoxic agents and pre-existing neuropathy as well as diseases/deficiencies that predispose to neuropathy should also be considered as potential risk factors for PN development,[24,26,31] including renal insufficiency, hypothyroidism, vitamin deficiency, human immunodeficiency virus (HIV) infection, and autoimmune rheumatologic conditions. Before initiating medications, nurses should assist the doctor to conduct a comprehensive neurological examination to determine and record the baseline status of neurological functions.[32] A comprehensive assessment should be simultaneously conducted to determine whether patients have the above mentioned risk factors for PN development to identify high-risk groups and adopt preventive measures in advance. Focusing on such high-risk groups could enable to detect neurotoxic-related manifestations earlier during the treatment course.

Screening of ADC-induced peripheral neurotoxic lesions for early detection and intervention

A key step for the appropriate management of PN patients receiving ADC treatment is the screening of PN for its early detection. Symptoms and functional deficits associated with PN should be screened and assessed before the start of each treatment cycle, and the findings should be compared with the baseline levels. Screening can be performed by actively observing patients.[33] For example, nurses can observe whether patients exhibit any abnormal gait or balancing difficulties while walking and whether patients show difficulty or abnormal performance of fine motor skills, such as wearing clothes, tying shoelaces, picking up small objects, and writing. Screening can also be performed by asking questions

to patients, for example, "is it difficult to feel the accelerator pedal while driving?" or "is there any tingling sensation in feet/hands or changes in sensation or pain ratings?" PN can be detected early through conscious careful observation and questioning. Early intervention could be implemented if problems in the patient are identified. Nurses could also refer the patients to undergo rehabilitation (e.g., physical or occupational therapy) and/or receive exercise intervention, if required.

Application of appropriate assessment tools to evaluate PN

Accurate and sensitive PN assessment tools are essential for clinical monitoring during treatment, follow-up of long-term outcomes, and measurement of toxicity in clinical trials. When a patient experiences neurotoxic reactions during ADC treatment, the nurse should be able to assess the severity of these reactions by using appropriate assessment tools to provide a basis for targeted treatment and nursing strategies. The commonly used clinical assessment methods include toxicity assessment tools, composite measures (combination of subjective and objective assessments), and patient-reported outcome (PRO) measures. The common therapeutic toxicity assessment tools include comprehensive criteria for assessing therapy-induced toxicity and National Cancer Institute-Common Terminology Criteria for Adverse Events (NCI-CTCAE 5.0).[34,35] Medical professionals can also determine the extent of nerve damage through clinical tests, including assessment of deep tendon reflexes, muscle strength, and loss of sensation. The Total Neuropathy Score (TNS) is a common comprehensive measurement tool that combines subjective symptom scores and objective scores of anesthesia and neuroelectrophysiological parameters.[23] PROs were determined using a series of standardized questionnaires to collect information directly from patients regarding their health status, functional status, and treatment experience, without any explanation from healthcare providers or other persons.[36] Common PRO tools include Chemotherapy-Induced Peripheral Neuropathy Assessment Tool,[37] European Organization for Research and Treatment of Cancer Quality of Life Questionnaire-Chemotherapy-Induced Peripheral Neuropathy (QLQ-CIPN20),[38] Functional Assessment of Cancer Therapy/Gynecologic Oncology Group–Neurotoxicity,[39] and Patient Neurotoxicity Questionnaire.[23] These evaluation methods and assessment tools have their own advantages and disadvantages. In clinical nursing, it is necessary to comprehensively consider clinical environment, evaluation purpose, patient characteristics, and other factors to select the appropriate assessment tool for professional and complete evaluation, and the assessment should be performed throughout the entire treatment process.

Close monitoring to ensure patient safety

PN causes numbness or tingling in the extremities and affects daily life activities, thereby increasing the risk of falls. Argyriou et al. surveyed 122 cancer patients who experienced any grade of PN; of these, 21 patients (17.2%) with a mean age of 57.3 $\pm$ 8.1 years reported falls after completing different treatment regimens. The results of the clinical edition of the TNS revealed that all 21 patients with falls had Grade 3 PN.[40] Therefore, the prevention of falls is an important part of the safety management of patients with ADC-induced PN. Before the start of treatment with ADCs, nurses should understand the patient's medical history, complications, and their treatment course and then perform a detailed recording of their health condition. The nurses should conduct further neurological examination and record any sensory and motor abnormalities that may be present.[23] Subsequently, the main clinical symptoms should be assessed based on the following aspects:[41] (1) whether the distal extremity of the limb is mainly involved; (2) whether the lesions are related to the use of therapeutic drugs; and (3) lesion severity is determined according to both physicians' and patients' assessments. After determining the presence/absence of pre-existing PN and its severity, the fall risk of patients can be further assessed. Experts recommend the use of the Morse Fall Scale, whose evaluation items include fall history, number of medical diagnoses, requirement for walking assistance, details of intravenous therapy, gait, and cognitive status; scores of 0–24 are classified as no risk, 25–45 as low risk, and $>$ 45 as high risk.[23] As the drug therapy progresses, nurses should regularly evaluate the patient's behavior, body balance, cognitive function, and other potential risk factors and determine whether physical therapy or neurocounseling is required.[33] Based on the evaluation results, personalized support and guidance should be provided to avoid accidental injury and ensure smooth progress of treatment.

Provide health education to improve patients' self-care ability

The occurrence, development, and prognosis of PN follow a relatively long-term process, during which the patient's self-care ability is particularly important for effective symptom management and prevention of secondary injuries. The nurse should encourage the patient to promptly report any numbness or tingling symptoms to the medical staff during the treatment course. The nurse should also be aware of the status of patients' safety at home and discuss with their family members regarding suggestions for changes in gait, dropping objects, or changing use of hands over time and then provide appropriate education to improve the patients' home self-care ability and ensure their safety. Patients with hand-foot numbness are required to be specifically educated on the following five preventive measures: prevent falls, prevent dashing to any objects, prevent scald burns, prevent frostbite, and prevent injuries from sharp instruments. Education to prevent accidents mainly includes:[23,26] (1) choice of shoes and clothing: flat shoes covering toes and heels should be used when going out or while walking in a room. High heels, platform shoes, or slippers are strictly prohibited for external use. Moderate size trousers with a tight waistband should be worn in case of tripping off; (2) prevent scald burns: avoid contact with heat sources (boiling water, hot utensils, open flame, etc.), use hot water with the assistance of family members, pour cold water first and then add hot water if there is no person to help, and avoid being outdoors for a long time at noon in summer to prevent sunburns; (3) prevent frostbite: keep oneself warm in winter, wash with normal temperature water as much as possible, wear gloves and thick socks outside home, avoid touching frozen items for a long time, and reduce direct contact with iron-made items in cold places; (4) prevent sharp instrument injury: avoid using scissors, fruit-cutting knives, and other sharp instruments and take help from family members if required; and (5) residence environment:[26] ensure that the room is well lit, install handrails in the living room and bathroom if possible, install non-slippery flooring and avoid the use of loose carpets, and avoid clutter of indoor items at home.

Multidisciplinary collaboration for follow-up management to improve patients' quality of life

ADC-induced PN is characterized by a diverse range of clinical manifestations, and multidisciplinary team collaboration is critical to ensure appropriate management of PN symptoms. The entire management process requires the cooperation of staff from oncology, neurology, pharmacy, nursing, and other disciplines to yield maximum benefits of multidisciplinary management and enhance the safety of ADC treatment.[42] For instance, the National Cancer Policy Forum 2018 report suggests that rehabilitation providers should be included in the cancer care team from the time of diagnosis, and their expertise should be continued throughout the care process. To reduce the burden of treatment-related toxicities, individuals should be allowed to maintain their highest level of functional independence; furthermore, to improve long-term quality of life, the report specifies that patients should be screened regularly for rehabilitation needs, particularly during treatment with neurotoxic drugs.[43] It can also be completed by oncology nurses with rehabilitation knowledge, which can not only provide more convenient professional support for patients but also expand the scope of nursing practice. In this patient care model, preventive care and education can be provided early, PN and functional deficiencies can be

screened, and prompt referral can be provided to receive professional rehabilitation intervention.

According to the current studies, the median time for remission of symptoms of ADC-induced PN is 1–45 months. Although patients usually present with Grade 1-2 PN, a long-term rehabilitation process is required. Therefore, the management of PN requires continuous and dynamic monitoring and management. Regular follow-up is critical to improve patients' quality of life, ensure better PN symptom management, and promote rehabilitation management. Follow-up should include monitoring of patients' general conditions, neuropathy symptoms, daily functional activities, mental and psychological conditions, and concomitant symptoms. Presently, patient follow-up is achieved through diverse methods, and the management of symptoms and adverse effects in patients receiving chemotherapy could be used as a reference guide for the follow-up management of patients receiving ADCs. Several Chinese studies have investigated the use of evidence-based protocols,[44,45] a graded prevention program,[46] and a patient security management path,[47] for managing PN symptoms induced by anticancer therapy. These studies have a solid theoretical basis, with robust clinical application results; moreover, these studies have proposed some guidelines for clinical nursing. With advancements in technology, web-based educational programs are being increasingly used for remote symptom management and for improving the quality of life of cancer patients.[48] Kolb et al. developed a new care model, namely SymptomCare@Home, with automatic symptom monitoring and guidance system. This model effectively identifies neurological symptoms and their severity; moreover, combined with the follow-up of advanced practice nurses, this model has achieved remarkable results in reducing the incidence, severity, and pain of symptoms.[49] Additional studies have shown that PROs can supplement the interpretation of clinical results in medical big data studies. Real-time health status monitoring, which is particularly suitable for home follow-up, can help promote early screening of symptoms, optimize accurate management of symptoms, and predict disease prognosis.[50] Different follow-up modes have their own advantages, and the appropriate follow-up approach should be selected based on existing resources and patients' willingness.

Conclusions

ADCs are being increasingly used for treating cancer patients in clinical settings, which not only provides survival benefits to these patients but also induces adverse effects because of the specific structure and mechanism of action of these drugs. Although ADC-induced PN mostly presents as a Grade 1-2 condition, the symptoms persists even after the end of treatment. Patients with PN experience subjective sensory discomfort, which may further lead to self-care disability and safety issues in daily life as well as additional damage and treatment costs, which should not be neglected.

As an integral member of the multidisciplinary team, nurses play a crucial role in the prevention and management of adverse effects of anticancer therapy. A comprehensive assessment of the risk factors causing PN can help identify high-risk groups and enable to focus on their treatment. Dynamic monitoring and regular screening of neurological functions can allow early detection of any abnormalities. For patients with PN, suitable assessment tools should be selected to determine its severity and for providing appropriate treatment and management. Nurses should simultaneously attempt to educate the patients, improve their self-care ability, and ensure their safety. An effective and feasible follow-up model should be developed for continued patient management to boost their recovery.

Although ADC-induced PN mainly originates from the toxic payloads of drugs, the mechanism is similar to that of CIPN, and the previously established management approaches for CIPN can be used as a reference. Furthermore, there are many types of ADC drugs, with diverse drug structures and components and complex treatment schemes. Therefore, the characteristics of the adverse effects are different from those of PN caused by chemotherapy alone. Hence, it is suggested to conduct relevant studies on different ADCs and treatment schemes in the future to provide more valuable guidelines for clinical nursing.

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CRediT authorship contribution statement

Jie Zhang: Conceptualization, Data curation, Writing- Original draft preparation. Hong Yang: Data curation, Writing- Original draft preparation. Yuhan Lu: Formal analysis, Supervision, Writing- Reviewing and Editing. All authors had full access to all the data in the study, and the corresponding author had final responsibility for the decision to submit for publication. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

Declaration of competing interest

The authors declare no conflict of interest. The corresponding author, Prof. Yuhan Lu, is an editorial board member of *Asia–Pacific Journal of Oncology Nursing*. The article was subject to the journal's standard procedures, with peer review handled independently of Prof. Lu and their research groups.

Data availability statement

Data availability is not applicable to this article as no new data were created or analyzed in this study.

Declaration of generative AI and AI-assisted technologies in the writing process

No AI tools/services were used during the preparation of this work.

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